Journal
of
The Franklin Institute

EDITOR, HENRY BUTLER ALLEN, MET.E., D.Sc.
ASSISTANT EDITOR, JOHN FRAZER, PH.D.

Associate Editors:

WILDER D. BANCROFT, PH.D.
C. B. BAZZONI, PH.D.
E. G. COKER, F.R.S.
ARTHUR L. DAY, SC.D.
R. EKSERGIAN, PH.D.
A. S. EVE, F.R.S.
PAUL D. FOOTE, PH.D.
W. J. HUMPHREYS, PH.D.
C. E. K. MEES, D.SC.
WILLIAM B. MELDRUM, PH.D.
HENRY C. SHERMAN, SC.D
W. F. G. SWANN, D.SC.
HUGH S. TAYLOR, D.SC.
A. F. ZAHM, PH.D.
JOHN ZELENY, PH.D.

Committee on Publications:

G. H. CLAMER, CHAIRMAN
RICHARD HOWSON
C. L. JORDAN
LIONEL F. LEVY
MALCOLM LLOYD, JR.
HIRAM S. LUKENS
RICHARD H. OPPERMANN
WINTHROP R. WRIGHT

Vol. 239 **FEBRUARY, 1945** **No. 2**

CONTENTS

Certain Applications of Physical Principles to the Playing of Musical Instruments. W. F. G. SWANN 79

Progress of the Biochemical Research Foundation of The Franklin Institute—1943–1944 ELLICE MCDONALD 87

Sensitivity Distribution Among the Grains of Photographic Emulsions. A. P. H. TRIVELLI 101

Impact Determinations Based on the Arrested Fall of a Body. L. F. DYTRT AND W. SPECHT 115

Notes from the National Bureau of Standards 127

The Franklin Institute Notes 133

Notes from the Biochemical Research Foundation 150

Abstracts

The BRF Blood Plasma Substitute and Its Restorative Effect After Acute Hemorrhage J. O. ELY

Book Reviews 153

Publications Received 156

Current Topics 86, [100, [114, 126, [132, [142, 157

Published by

THE FRANKLIN INSTITUTE OF THE STATE OF PENNSYLVANIA

Prince and Lemon Streets, Lancaster, Penna., and Benjamin Franklin Parkway at Twentieth St., Philadelphia, Penna.

SIX DOLLARS PER YEAR (Foreign Postage Additional) **SINGLE NUMBERS, SIXTY CENTS**

Indexes to the semi-annual volumes of the JOURNAL are published with the June and December numbers. The contents are also indexed in *The Industrial Arts Index.*

Journal
of
The Franklin Institute
Devoted to Science and the Mechanic Arts

Vol. 239 FEBRUARY, 1945 No. 2

CERTAIN APPLICATIONS OF PHYSICAL PRINCIPLES TO THE PLAYING OF MUSICAL INSTRUMENTS.*

BY

W. F. G. SWANN,

Director, Bartol Research Foundation of The Franklin Institute, Swarthmore, Pennsylvania.

(*Continued from January issue.*)

CERTAIN CHARACTERISTICS OF THE EAR.

This is as convenient a place as any to call attention to certain circumstances, some of them perhaps unfortunate, which arise from the fact that the entities which listen to the playing of instruments are human beings.

Loudness Versus Acoustical Energy. The first of these matters concerns the relation between sound intensity, as measured by the acoustical energy received by the ear, and loudness, as appreciated by the ear. If we double the intensity of a sound in the sense that we double the energy which the ear receives, the effect upon the ear is not such as to convey an impression of anything like a factor of two. I am well aware of the fact that loudness as appreciated by the ear is a very vague concept and I have no time to discuss the history of the matter. It will suffice to say that if we are to compare quantities which are to be satisfactory to the ear as relative intensities, they must not represent ratios of actual sound energy, but rather the logarithm of such ratios. Put less mathematically, I may say that if I should plot the sound energy entering the ear along a horizontal axis and the quantity which the ear would be content to regard as loudness along the vertical axis, the curve would be similar to Fig. 11. In other words, to double the aural loudness, we have to very much more than double the energy of the sound. Bringing this down to a practical case, we

* Presented at the Stated Meeting held on March 15, 1944. The text of this paper will be presented in semi-popular vein. However, the paper will be supplemented by more technical footnotes and by an appendix, which will appear at the end of the third section of the paper, and to which reference will be made in the text.

(Note—The Franklin Institute is not responsible for the statements and opinions advanced by contributors in the JOURNAL.)

may raise with ourselves the question, for example, of an orchestra conductor who starts out with one first violin. He engages another and finds he gets a change in loudness. He would like to double the change in loudness. He will find that he must have four violins. He would like to triple the change in loudness. He will find that he must have eight violins. He would like to quadruple the change. He will find that he must have sixteen violins. He would like to have ten times the change. He will find that he must have 1,024 violins. I think that perhaps I had better say no more about this matter, as I do not wish to discourage unduly the Boards of Directors of Symphony

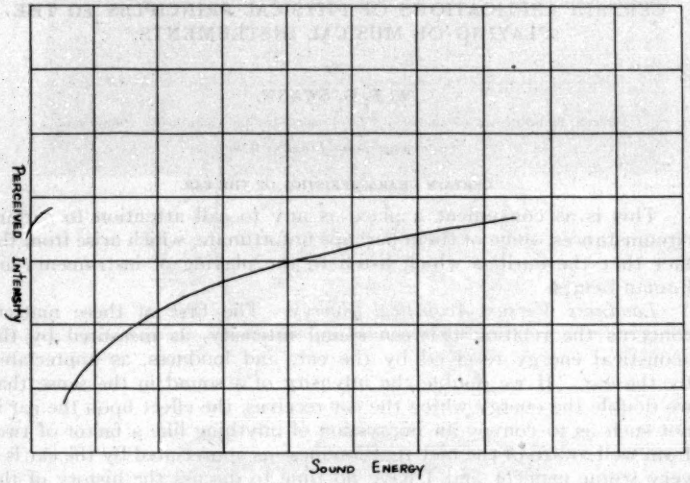


FIG. 11.

Orchestras who have to supply funds, nor do I wish to put ideas into the heads of the Musicians' Union.

However, there is a compensating feature arising from the fact that the ear is much more intrigued by changes of intensity than by an average level of high intensity. We are all familiar with those acoustical monstrosities which play hymn tunes electrically on street corners at Xmas time. They do not sound extraordinarily loud, but you can hear them for ten blocks. Nobody could hear a man singing for ten blocks from a street corner in opposition to the noises of city traffic, and these contrivances must indeed be very loud. Once the ear has accommodated itself to the loud intensity, it ceases to be impressed, however.

In fact, I am inclined to think that the ear ceases to be impressed

with anything which remains continually the same. The ear is more impressed with a crescendo or a diminuendo than with a constant sound. However, it is still more impressed with a crescendo which itself increases, so that, as I believe most orchestral conductors will agree, it is well, frequently, in approaching a climax, to make the crescendo gradual at first and then much greater towards the point of attainment of the climax. This matter has even more subtle ramifications, for it is my own experience that if we make all instruments of the orchestra crescendo together in like amounts, the balance will not be properly preserved, or at any rate it will not be agreeable, whereas if the strings, for example, crescendo more or less gradually while the greater part of the crescendo of the brass is left to the climax, then not only will the brass fail to predominate over the strings during their crescendo, but even in the rapid brass crescendo at the end, the strings will be evident. The ear can tolerate and enjoy a tremendous blast of sound from a strong instrument in the right place, and so long as that sound does not extend over into the future or the past beyond its proper territory, it will not drown out the weaker instruments, but one smudgy second violin, floundering along with the wrong intensity of tone for the place concerned, possesses the power to smother, or at any rate blur, much more potent sound-producing instruments which are playing along with it.

Power of the Ear to Discriminate Between Sounds: Power of the Ear to Manufacture Sounds. The ear is a very peculiar mechanism. It possesses the power to do something which no man-made mechanism has ever succeeded in doing. In a mixture of different kinds of sound—different people talking, for example—it can decide to pick out one voice and enable the brain to concentrate upon that without any particular regard for the others. Moreover, as we have seen, the response of the ear is not proportional to the intensity of the sound. If we play a certain note and then increase the physical energy radiated in that note by a certain amount, the effect on the ear produced by that increase will be less the larger the amount of the energy radiated before the increase. To put the matter in a very crude way, sound tends to paralyze the ear and make it insensitive to the addition of more sound. Now it is naturally to be expected that such effects will depend upon the kind of sound concerned; that in the case of pure notes, for example, they will depend upon the frequencies of those notes. It is, I believe, recognized by authorities on psychological acoustics, that a faint sound will not be heard at all through a louder sound of the same pitch if the difference of intensity is more than a certain limiting amount, while the difference in loudness may be greater if the sounds are of very different pitch.[28]

Moreover, the ear and its associated mechanisms, including the brain, have another curious characteristic, namely that of creating for

[28] See J. H. Jeans, "Science and Music," The Macmillan Co., p. 230.

themselves sounds which do not actually exist in the sounding mechanism. In particular, if we suppress the fundamentals in the notes constituting a tune and retain only the overtones, the ear will reconstruct out of the overtones the original fundamentals and will in actuality hear the tune in spite of the fact that it is not being played. The Bell Telephone Company has constructed sets of gramophone records which illustrate these matters very clearly, and through the courtesy of that company, it is my good fortune to have some of such records here this evening. I shall concentrate upon two of these records. The explanations of the records are incorporated on the discs themselves.[29]

The first record is designed to illustrate the role of overtones in determining musical quality. Three instruments, piano, 'cello, and french horn, are used, all sounding middle C, which has a frequency of 256 cycles per second. Each instrument has a distinctive and characteristic sound, depending on its overtones, and as they are played in succession, you will have no difficulty in identifying them. Operating in conjunction with the apparatus cutting the record are filters capable of eliminating any vibrations above any desired pitch. These will be connected into the circuit one after another to show the effect on the quality of the sounds. The first filter will eliminate all overtones, leaving only the fundamental, and you will notice that the three sounds become almost indistinguishable. A filter eliminating all frequencies above 750 cycles, now inserted, will pass the first overtone in addition to the fundamental. In the sounds heard as a result, you will notice the beginning of a quality differentiation. The next filter eliminates frequencies above 1,400 cycles and so admits the second, third, and fourth overtones. Whether the enrichment of tone is proportional to the number of additional overtones admitted depends entirely on the importance of the various overtones to the sounds of that particular instrument. The next filter admits all overtones up to and including the ninth, and you will notice that some of the sounds have now attained almost a normal quality. The following and last filter will admit all up to and including the seventeenth overtone, and a further filling out of some of the sounds will be noticeable.

The next record will illustrate for the piano, 'cello, and french horn the power of the ear to reconstruct the fundamental from its overtones. We shall first obliterate, by means of an acoustical filter, the fundamental vibration of each instrument and then at each step more and more of the lower overtones. You will notice that the arrangement of the overtones for the three instruments is different, the higher overtones being more conspicuous in the sound of the piano and 'cello than in the french horn. The normal tones of the three instruments will first

[29] The description which follows is taken, practically verbatim, from the description on the discs. The illustrations, of course, followed the descriptions in the actual lecture, and naturally cannot be reproduced here. However, the text itself will serve to indicate what was observed.

be sounded. The filter will next be adjusted to eliminate the fundamental frequency of 256 cycles, leaving all of the overtones. The next filter cuts out the frequencies below 800, and therefore eliminates the first and second overtones as well as the fundamental. The next filter cuts out all frequencies below 1,600, eliminating therefore the first five overtones. The filter will next be adjusted to cut out the lowest ten overtones.

In the demonstration as given, the ear remained distinctly conscious of the fundamental after it had, in actuality, been eliminated by the filter; and indeed, the fundamental appeared to persist, in perhaps decreasingly prominent degree, as the higher overtones were successively eliminated, so that even the overtones above the tenth possessed the power to recall that fundamental to the ear, in spite of its physical absence from the apparatus.

The principle illustrated by the foregoing records is utilized in practical application. Organ builders utilize it to get tones of low pitch without the expense of pipes of great length. Similar things happen in relation to the lowest notes of the piano. It seems likely that the ear hears only the overtones of these notes directly and creates for itself the fundamental as what is called a "difference tone."

THE CARRYING POWER OF STRINGED INSTRUMENTS.

There is an interesting term which has a very definite place in the vocabulary of the artist but which, so far, seems to have a much less definite place in the vocabulary of the scientist. It is the term "carrying power." There is a widely prevalent belief to the effect that the tone of certain instruments somehow or other goes farther than that of others. To put the matter in more precise terms, I presume that the devotees of this belief would maintain that it is possible to have two instruments which, when yielding the same intensity of sound to a receiver placed near to them, would deliver different intensities of sound to a receiver placed far away from them. The implications of this statement do not leave the physicist in a very happy frame of mind. However, I am not willing to deny the possibility that, under suitable conditions, two instruments which sound alike to the ear when played near to it, sound differently as regards intensity when played far from it. The explanation of such phenomena is to be sought in the peculiarities of the ear which we have just discussed.

In an auditorium, particularly one filled with people, and even people who are more or less still, there is a good deal of noise, and this noise extends over all frequencies in the acoustical spectrum. It is as though someone had a harp with very many strings and, with a multitude of fingers, was playing them all continuously. The net result of this is to produce something which sounds unlike any one note and sounds, in fact, like nothing in particular. It represents a kind of basic sub-stratum of noise which the ear accepts without

necessarily being conscious of it. It would only become conscious of how much noise there was if it were suddenly transported to a place where there was no noise. City dwellers, who are not unpleasantly conscious of a continual rumble, have a marvelous sense of quietude when they suddenly spend a night in the country, if there are no crickets and owls about.

Now an ear which is experiencing a sound is rendered thereby less sensitive for the addition of more sound of the same kind. The fact already cited to the effect that ear perception increases less rapidly than sound energy responsible for the perception is a particular example of this fact. In the auditorium, therefore, no matter what note you play, there is somewhere a competing note which is tending to reduce the sensitivity of the ear in the matter of its reception. However, the note which is being played is reinforced by all of its overtones, which tend to recreate in the mind any loss which the ear may experience in direct reception of the fundamental. Of course, all of these overtones are being affected, as regards sensitivity of their reception, by their corresponding notes in the general noise of the auditorium. However, it is reasonable to suppose that in view of all the circumstances cited, a weak note of a certain quality, as determined by its overtones, will have a different chance of surviving the competition of the auditorium than the same note of equally small intensity but of different quality. If such be the case, we should be liable to experience a situation such as the following:

Suppose that two instruments, A and B, of different quality are played on the platform of an auditorium, so that they sound alike in intensity to one who sits near. Then if the auditorium is perfectly silent, they may well sound alike as regards intensity at the most remote point, although of course, the intensity will be much reduced there. If we now fill the auditorium with that kind of mixture of sound which I have called general noise, it may well be that the note played by one of these instruments will be imperceptible to the ear, whereas the other may survive.

Of course, a much greater potentiality for acoustical competition occurs when an instrument is being played as a solo instrument through an orchestra as an accompaniment. Here there is no question of the reality of the dulling of the sensitivity of the ear even of the player to his own playing as the result of the competing sounds around him, even when the sounds are not loud. As a matter of fact, a smudginess in the accompaniment is liable to be more disastrous in drowning out the player than even a somewhat louder intensity played with clarity and precision. Here again, the same elements as regards the potentialities of different instruments to sound through the orchestra have significance.

In addition to the foregoing elements, we have to recognize that through impact of the sound waves upon the walls of the auditorium,

the components of the sound become reduced, by absorption, in varying degrees. Such a circumstance may have a discriminating effect in relation to two instruments; for if both instruments are relying upon certain overtones to recall a weakened fundamental, and if these overtones are highly absorbed by the wall, the loss in their intensity will be of less account in the instrument which is rich in them than in the instrument in which they are weak.[30]

[30] Following the lecture, I discussed the matter of carrying power with Professor Charles Weyl, who was present. Professor Weyl has himself made investigations of this matter, and I asked him to send me a brief statement of his conclusions, which he was so good as to do, and with his permission, I incorporate his general conclusions as follows:

"In general I found that for a given sound energy level at a distant point from a single instrument in an empty auditorium, seating capacity approximately 300, with a time of reverberation of approximately 1½ seconds, those instruments in which the higher harmonics (particularly the seventh, ninth and eleventh) were predominant showed a definite increase in apparent carrying power. This was especially true for sustained tones in the middle register, let us say the two octaves up from middle C. The same result was noted to a lesser degree and with less certainty for the ranges below middle C and above two octaves above middle C. The phenomenon is also less striking for rapid passages and as far as my experiments went were completely inconclusive with respect to any one instrument in an ensemble.

"Offhand these results appear to be in accord with the known theory. Some of the factors contributing to the explanation appear to be as follows:

"1. The ear is most sensitive in the region from 2,000 to 5,000 cycles and on the average shows a marked decrease in sensitivity (approximately 10 decibels) with respect to the maximum near 1,000 and 8,000 cycles. Beyond these latter points the sensitivity decreases very rapidly. Hence any instrument which produces strong overtones in the optimum sensitivity region will naturally appear to be louder, that is, have better carrying power than one in which these overtones are weak with respect to the fundamental.

"2. Fletcher and Munson studied the loudness of a complex sound and found that as judged by the ear the apparent loudness approached the sum of its components when and only when these components differed in frequency by approximately 400 cycles or more. This would tend to account for the importance of the higher harmonics in the middle range of an instrument such as the 'cello. These harmonics are separated far enough from the fundamental and from each other to get a maximum loudness effect and they fall in or near the region of optimum sensitivity of the ear. Also, masking by the fundamental and lower harmonics should not play much part in the apparent loudness under these conditions.

"3. As the distance from the instrument to the listener increases, the absolute level of all frequencies decreases in a room of average or smaller than average reverberation time. This decrease may and often does bring the fundamental and lower harmonics, as well as the very high harmonics, those in the region of 8,000 to 15,000 cycles, below the threshold of hearing, particularly in the presence of the almost inevitable extraneous room noises. Consequently the farther away one gets from the source of sound, the more important become the harmonics in the region of optimum aural sensitivity. The carrying power of the instrument might naturally be judged on the basis of the intensity of these harmonics. As is well known, if the fundamental is depressed below the threshold of hearing, it is physiologically supplied by the action of the harmonics on the cochlea of the ear.

"These observations are further strengthened by the fact that in a highly reverberant room, particularly one in which the wall, floor and ceiling surfaces show very little frequency selectivity with respect to the absorption of sound, the difference in carrying power so clearly observable in the experiments I mentioned above for a room with a reverberation time of approximately 1½ seconds, becomes greatly diminished, or absent."

(To be continued)

Counting Calories.—Discussing food needs for the human body's energy, Dr. H. C. Sherman, nutrition authority of Columbia University, formerly of the U. S. Department of Agriculture, says that a helpful fact to remember is that an average man sitting still spends about 100 calories of energy an hour.

The "yardstick of good nutrition" provides for 2,500 calories from food as a daily allowance for a sedentary man, 3,000 for a moderately active, and 4,500 for a very active man. Women are estimated to have four-fifths of the body weight of men, and their corresponding allowances are: Sedentary, 2,100; moderately active, 2,500; very active, 3,000 calories. Those who eat food supplying more calories than they need often gain unwanted weight.

Healthy children should be active, and the "yardstick" allows them from 1,200 calories a day at one year to 3,800 calories for fast growing boys of from 16 to 20 years.

Energy is provided by proteins, fats, and carbohydrates in foods.

Dr. Sherman cites some common foods showing how much of each will provide 100 calories: Butter (nearly pure fat), about half an ounce—a generous pat. Bread, an ounce and a third—a thick slice or two thin ones. Milk, about 5 ounces—two-thirds of a full-sized glass or cup. Potato—5 ounces—a fair-sized potato. Apple—7 ounces—one good-sized apple.

Although it must never be forgotten that the body needs nutrients, other than those that merely furnish energy, the 100-calorie measure is often convenient in checking over food needs for the day. Too high a food calorie intake for the amount of energy expended leads to overweight, and for normal persons, says Dr. Sherman, the principle of controlling body weight is to eat just liberally enough to have the body weight one wants.

R. H. O.

PROGRESS OF THE BIOCHEMICAL RESEARCH FOUNDATION OF THE FRANKLIN INSTITUTE—1943–1944.*

BY

ELLICE McDONALD, M.D.,

Director.

This has been another year of research influenced by war. Only that which has nothing to do with our war effort can be told to you tonight. Still there is some that may interest you.

We began to prepare for the war years in 1937, but, in spite of some foresight, many things have occurred which were not foreseen and which influenced our research. We have carried on and maintained our organization without unduly diverting our program.

Certain new discoveries have altered our research plans. One of these is the re-discovery and application of the sulfa drugs to the treatment of pneumonia. We had a large project planned for the study of pneumonia vaccine by means of physico-chemical methods for which we are so well equipped. Sulfa drugs came in and pneumonia vaccines were rendered obsolete, so a great deal of our work went for naught. However, it now seems that certain types of pneumonia are resistant to sulfa drugs and there is a field again for the study of vaccines.

The mortality from pneumonia under sulfa drugs has been reduced from an average of 20.8 per cent. to 3.9 per cent. in a short space of time and the average duration of the illness from 38 to 27 days. Throughout the country it can be estimated that about 60,000 lives are saved yearly so that this disease has been demoted from its rank. The people of these United States have benefited by the saving of these lives and so also have the Life Insurance Companies although they have done nothing and have given nothing for research to help bring this about nor have they promoted any research into disease. This policy is short sighted, for the addition of two years' life to the policy holders of the Big Five Life Insurance Companies would be worth millions to them, but they are content to sit by and reap the harvest sown by others. This policy is not only unintelligent but selfish.

We have had to put aside a number of other research projects to engage in the more opportune studies required by the war. One occurrence which has made directorship hard has been the loss of our trained people. We expected that those who were reserve officers or fit for war should go, but I confess I did not forsee that so many would be tempted away to other government agencies, drug companies, etc.

* Presented at Stated Meeting held on November 15, 1944.

This has made it difficult to maintain our staff and it is to be hoped that those leaving in this fashion will be equally happy in the post-war time.

It is also more difficult to get the quality of young men required for training as we delighted to do before the war. These are in the armed forces or in other governmental positions.

No matter how much research is organized, the worker is the unit. Houses are arranged habitations but the building block is the unit. Without careful choice of the unit no research can be successful. After all, it is the men who do the work.

There is no royal road to success in choosing men. Part of it is experience—in life as well as in science, but a good bit of it is a gift, a quality of estimating men and their capacity in a short time and a wise director is one who pays particular attention to the choice of his personnel. The power of organization is great and the effect of a few may be multiplied almost indefinitely and what one individual can accomplish may not be great, but if the units are not carefully chosen, the aggregation into an organization will suffer.

Of course, the choice must be limited by the type of research organization in question. In an industrial research, there must be profits to keep the show going: in some, there are more immediate demands for profits from research than others. Some are so short sighted as to require research to produce results forthwith—"Put in the thumb and pull out a plum." This is as unsatisfactory as is the long time research in universities which often continues on and on without a definite aim but goes by continuation and often becomes merely a multiplication of detail.

At one end is technology and at the other is abstract science. One looks upon the other as academic and the other scorns the one as merely practical. The classification of science as organized knowledge is confusing because it suggests an entirely artificial separation between pure science and technology. Civilization began in technology and pure science arose when technology made possible the leisure necessary for its pursuit: but today the applied scientist uses the same strict criteria of accuracy and logical evaluation as does the pure scientist. Actually there are all graduations and no definite division except at one end is the shop laboratory to control the quality of product and at the other end is the cloistered pure scientist remote from the world and who may or may not produce a valuable result.

Should all results be valuable? Practical necessity may not be required for scientific advance and many inventions of apparatus devised for scientific advance have been subsequently transferred to practical use. As examples of such inventions, Haldane cites the telescope, the cinematograph, barometer, gasometer, galvanometer and cream separator. Most of these have to do with measurement and are really of the nature of scientific aids to extend man's senses and powers

of observation. But after all, most of us are inclined to what Benjamin Franklin called "useful knowledge." Still it is a fallacy to suppose that scientific results come only in response to material needs.

In general, there is some futility in planned research toward a definite end: but there is as much futility in research without planning. The great mass of academic research is of that character. This does not mean that the first is technology or applied science and the second pure science or fundamental science so-called.

Still in research, as in any other modern phase of effort, it is better to start with a plan and that plan must influence the choice of workers who must carry it out. The field of scientific effort is so great that it takes more than one mind to encompass it. So comes specialization.

When the scope of the research is known and the areas of science well defined, then begins the scrutiny of those who must carry it out. The ideal is the exceptional man but is he to be recognized? The celebrated German chemist, Wilhelm Ostwald, was once asked by a Japanese student of his, "How are you likely to predict what members of a class are likely to distinguish themselves in science?" It was asked because the Japanese Government sent several hundred young men annually to foreign universities and wanted to get the largest possible return for the financial and human investment. To clarify his own mind, Ostwald wrote his "Groesse Maenner" in which he examined the great in science, only to reach the conclusion that, not only do we fail to recognize budding geniuses, but that we and our educational institutions do our best to treat them as white crows.

While it is difficult to pick genius in the bud, that is no reason why there should not be some discrimination in the choice of young research workers. The first requirement is that they should want to work. Once in the civil war a widow brought her son to President Lincoln, looking for a job for him and saying that he wanted to work. Lincoln sent him with a note to Stanton, Secretary of War, "This young man says he wants to work. This is so rare a desire that nothing should be put in its way." Pasteur, as he lay dying in his seventies, turned to his faithful and devoted students and said, "Where are all of you? What are you doing? You must work."

The research worker must be a worker. Every student should realize that enduring results are only obtainable through a series of small but continuous daily efforts. Knowledge, whether in science or art or in any human occupation, can only be achieved by daily toil and effort. Time is very vindictive and takes a cruel revenge on everything accomplished without its coöperation. The motto of the library of the Biochemical Research Foundation is "There is no substitute for time."

There must be a consideration whereby the man must be driven to act so as to go against the principle of Epstean's law that man tends always to satisfy his needs and desires with the least possible exertion.

This may be true in general, but not in particular. But no doubt there must be a compelling impulse. Thomas Alva Edison's wall motto must have been of the nature of a continual spur and reminder to him, "There is no expediency to which man will not go to escape the real labor of thinking."

In research, a man must be imbued with the *ardor* of science. He must have a consuming desire to find out about things and to make them work better. As Willstaetter has said, "Our destiny is not to create but to reveal."

Through many years the question has been asked as to what impels a scientific research worker upon his continued course. Some have answered that insatiable curiosity is the answer; others that man is a born explorer. The spirit of adventure has existed within him since time began. He has ever been trying to extend the frontier, to go over the next hill to see the vision, to find something he did not know and understand.

The adventurous spirit of man (and research is a high adventure) with a burning desire to know things will drive him forward in research now that other frontiers are conquered. Now his weapons are stronger equipment, new instruments to extend his senses and measurements to a degree not considered possible a short while ago.

Some have said that the research man works for reputation or acclaim. This may undoubtedly enter into it, but it is only a part. The desire for accomplishment and the sense of achievement means more to the real scientist. An inward feeling of work well done weighs heavier than the gold of the medals. The greater one's accomplishments, the more intensely the smallness of one's ability is realized. It is through this feeling of inadequacy and insignificance that knowledge and achievements can continually progress.

The real research worker, however his impulse may be described, is driven by an inward force toward an unseen goal and he does not understand his impulse himself. It is more than insatiable curiosity: it is more than the exploration urge: it is best described in the words of Balsac, when writing of a medical friend and a painter friend, in their desires for discovery and accomplishment. "These passions which are unintelligible to the crowds are perfectly explained by that thirst for the ideal which characterizes creative minds." The creative ideal of course influences many types of effort other than research, but it is, no doubt, the compelling impulse in research accomplishment, dimly as it may be seen by those chiefly involved.

The creative mind has as its chief characteristic "imagination" and in research the quality is most necessary. Still even such a matter-of-fact man as Lord Kelvin has said "I think about the problem all the time and I gather all the information I can get about it and then, when I am perfectly saturated with the subject and think about it all the time,

at some point my mind takes a mortal leap past all the facts." Call this reverie, prevision or what you will, but it is the research imagination which is necessary to every one in science. More than the daily absorption in the task is required. It requires the projection of one's mind beyond the facts in that intellectual and imaginative institution which is called the research spirit. Occupation and routine are useless alone. Constant and persistent efforts do not alone suffice, but there must be the divine curiosity to search out new facts in regard to life and the environment in which life exists.

Hervey Allen in a recent book has given a good description of the single mindedness required with its qualities and defects: "Most people are diffuse or diverse in their interests, fortunately. What in the end attracts permanent attention and fixes a reputation in memory is a man with a single end in view, one which he pursues relentlessly. This lends a precision, and eventually an economy to his actions, in comparison with which the diffuse activities of more normal contemporaries seem trivial and merely time-passing. That a certain insane tenseness frequently accompanies the man of one purpose seems only to cast a more focused and strange light upon his doings. It accentuates him by contrast. And if, as frequently happens, the man with one idea has no fear of consequences in the attainment of his object, a 'hero' is in the making. Such a man can be completely rational about one thing alone. But he can often be superrational about that, and to be superrational is a characteristic of genius."

It may be that the research worker is not so extreme, but the good ones are tarred with this brush. He must pursue his aim relentlessly although that aim may be changed with changing conditions, that is, with greater knowledge and vision, the result of his own experiments or those of others.

No splendid isolation is possible for the scientific worker. On the contrary, it is one of the gravest dangers which besets the specialist and specialists we must all be today. The man who tends to do everything alone will never achieve anything. If the mathematician, the chemist, the physicist, the biologist, the engineer and others lose contact, their separate progress is likely soon to come to an end. Many gaps in the uneven front of research today are represented by unexplored fields which lie between the activities of two or more branches of science. These gaps can only be filled in by the interchange of ideas from day to day and over a long period of time because it is difficult for scientists in different fields to learn the *patois* which each speaks. Often the lack of interest of the specialist in problems which lie aside his own domain is due to a lack of understanding of the language in which the other scientist is speaking. Mechanical-mindedness is a peril to which the scientific worker and above all the specialist is exposed even more than his fellow men. Team work and coöperation are the only methods of

avoiding this depression and encouraging receptivity to new ideas. Vision and scientific imagination are the most important things in research. "If there be no vision, the people perish" and, if there be no vision in the scientific laboratory, the results are poor.

Innumerable trifles collected in an orderly mass although insignificant individually may, by vision and imagination, contribute largely to knowledge. Research requires more than patience, dexterity and exactness, necessary as these are now since the present criteria are more quantitative than qualitative. An army of excellent but very ordinary people are at present carrying on research into the minutiae of unimportance, but these are required to prepare for the exceptional man by whom real advance comes. Where would the world be without such exceptional men as Pasteur, Newton, Franklin, and other great men whose vision illumines the whole subject so that specialization could take it up and further elaborate it. Advance comes through the exceptional man.

In spite of having to side track a considerable part of our program due to war conditions, we have worked upon a number of outside problems.

We were interested in producing a typhoid vaccine after our new method and have done so, as well as doing a considerable study by means of electrophoretic analysis of the various protein fractions so as to find out the most potent fraction for the production of vaccine. Some of these papers have been published in the JOURNAL OF THE FRANKLIN INSTITUTE and this is the first time that these electrophoretic methods have been applied to the studies of typhoid and other bacteria.

V.23
1945

We have studied poliomyelitis virus and have produced a vaccine by means of inactivating the virus by certain wavelengths of ultraviolet light so that a vaccine for poliomyelitis effective for animals was produced. This paper was published in the *Notes of the Biochemical Research Foundation* in the JOURNAL OF THE FRANKLIN INSTITUTE.

We have studied *Pasteurella pestis* (plague) and separated protein fractions after treatment with supersonic vibrations so as to get the real toxin of the bacteria. This involved treatment by means of enzyme particularly the ribonuclease and the help of the electrophoretic methods. A paper upon the subject is in press.

We are continuing studies in regard to the synthesis of certain new chemical substances for intravenous use against certain infections. We have under way a study of the systemic effects of certain war gases.

One important study by Dr. Ely has been the production of an artificial substitute for blood plasma in shock from burns and from loss of blood. A preliminary publication has been made on this in the *Notes of the Biochemical Research Foundation* in the JOURNAL OF THE FRANKLIN INSTITUTE.

In burns, the great danger is the loss of blood plasma due to leaking

through the vessels and the concentration (hemoconcentration) of the red blood cells which cannot get through but remain in the blood vessels. This is almost equivalent to shock from hemorrhage. In shock, the volume of the circulating fluid must be restored and remain as nearly normal as possible. Saline solution will not do as it also quickly passes through the vessels: so some other substance must be used similar to the proteins in normal blood plasma to restore and maintain the volume of blood. Glucose should be there also to restore the energy. A basis of composition was taken from the medium necessary to sustain cell life in tissue cultures and after certain modifications gelatin and glucose were added.

The constituents of the BRF blood plasma substitute are shown in Fig. 1.

Constituents of BRF Plasma Substitute.

	Constituents.	Grams.	
Sol'n 1.	Gelatin, Baker's U.S.P.	5.400	
	Cysteine. HCl	0.018	
	Phenol Red	0.010	
	Sodium Chloride	1.440	
	Potassium Chloride	0.036	
	Calcium Chloride (anhydrous)	0.036	
	Magnesium Chloride. $6H_2O$	0.018	
	Sodium di-hydrogen phosphate	0.009	
	Distilled water		100 cc.
Sol'n 2.	Glucose	6.000	
	Distilled water		100 cc.

FIG. 1. Constituents of BRF plasma substitute.

This was found to be well-borne, non-toxic, easily sterilized, capable of being carried in a small package to which distilled water only is to be added. The mixture can be kept and transported to be used as required by the addition of water. The ingredients are easily obtainable.

In order to be sure of its effect many tests were made. It is shown in Fig. 2 that it equals blood plasma in its effect upon shock and hemoconcentration while saline has little effect. The dots show the number and time of injections and these should be given frequently. This is an advantage of the artificial plasma which can be used more frequently than human blood plasma on account of the difficulty of obtaining the human blood bank plasma. Seven hours is the critical interval when several injections are required. Each of the curves represents the composite picture of about 25 animals and it should be noted from the height of the hemoconcentration curve that the cases treated with BRF blood plasma substitute were of a more severe type than those treated with animal blood plasma.

The value of the BRF blood plasma substitute in hemorrhage has been proved by Dr. Ely by restoration to normal of animals after removal of sixty per cent. of the blood volume. These animals were to

all intent and purpose dead with respiration stopped and heart sounds inaudible. But immediately the substitute plasma was administered a prompt improvement in the heart action occurred although sometimes in these moribund animals artificial respiration was also required. This is significant of the value of this artificial plasma in sevère hemorrhage as well as in shock.

It was shown on growing animals that it was well utilized in growth (Fig. 3), that there was no toxicity and that the proteins were used by the body cells.

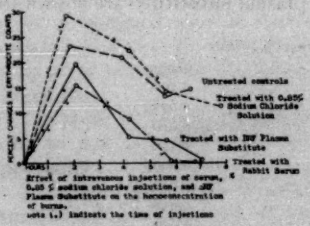

Untreated controls
Treated with 0.85% Sodium Chloride Solution
Treated with BRF Plasma Substitute
Treated with Rabbit Serum

FIG. 2. Effect of intravenous injections of BRF plasma substitute on the hemoconcentration of burns.

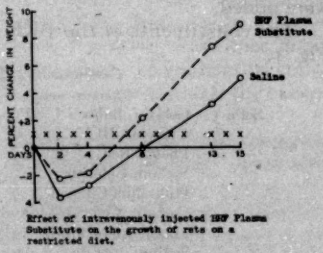


FIG. 3. Effect of intravenous injections of BRF plasma substitute on the growth of rats on a restricted diet.

The fate of the protein gelatin was particularly important as in real blood plasma injections the protein passes easily out of the blood vessel. Electrophoretic studies were done on rabbit plasma alone and rabbit plasma contains added gelatin (Fig. 4). This showed that gelatin retained its identity when mixed with rabbit plasma and it was possible to estimate the amount of gelatin by means of the electrophoretic pattern.

The electrophoretic method was also applied to a study of the retention of the gelatin within the blood vessel (Fig. 5) and showed that there was a gradual loss of injected gelatin from the blood stream and that the plasma proteins were essentially unaffected by the injected gelatin. After 24 hours the gelatin has practically disappeared.

These studies show that the BRF plasma substitute works well in shock from burns and its ease of production over blood bank plasma offers many advantages.

One interesting study in this connection was the discovery of what is supposed to be the toxic substance from injured tissues. This was extracted from the burned tissues and, when reinjected, produces the same kind of shock. The final product was thought to be largely adenosinetriphosphate.

As the labile phosphorus of adenosinetriphosphate exchanges readily, Dr. Ely gave rats intraperitoneal injections of radioactive sodium phosphate and prepared the shock factor from the muscles of the animals so treated by radioactive phosphate.

With the radioactive shock factor so injected, it was possible to follow the course in the animals' bodies by means of the Geiger Mueller Counter designed for use with fluids. This paper will appear in the *Notes of the Biochemical Research Foundation* in the next issue of the JOURNAL OF THE FRANKLIN INSTITUTE.

It was found that the lungs absorbed more of the intravenously injected radioactive shock factor than did the other organs. It was

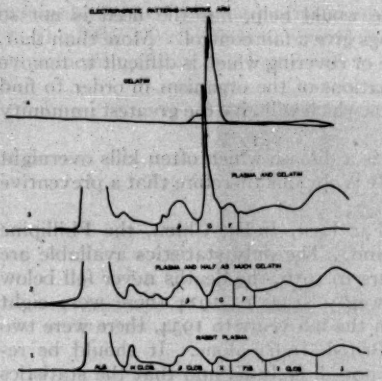


FIG. 4. Mixtures of gelatin and rabbit plasma *in vitro*.

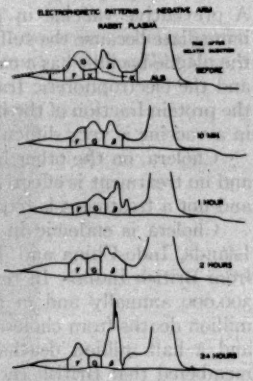


FIG. 5. The disappearance of injected gelatin from rabbit blood vessels.

removed quickly from the blood and the longer it remained in the blood vessels, the more delayed was the death of the animal.

When the radioactive shock factor was injected into the peritoneum, there was less accumulation in the lungs than in the liver, spleen, heart and kidneys. It may be that the effect upon the lungs is the most important factor in shock.

Another phase of our research has been the study of certain tropical diseases such as plague and cholera. The choice of such a subject came in our usual way. It was something we could do and something which the marvelous equipment in our laboratories allowed us to do. In choice of projects of research it is always well to choose what you think you can do. In the case of cholera, we acquired a man who had had nine years of study in cholera in India and, while it was true he had not got anywhere in his nine years, we thought if we backed him up with

our organization of trained workers and unique equipment that we might be able to achieve something. This turned out to be the case and in this it is mostly due to the ingenuity of one of our people, Mr. Jennings, with us for ten years, who discovered ways of producing the cholera vaccine.

Not only was that done but an entirely revolutionary method of preparing bacterial vaccines was discovered. This is applicable to many types of vaccines, a number of which, such as typhoid, are now being studied in our laboratories.

Plague is a different type of disease and a different study from cholera. Plague is a disease which kills more slowly and is cured in more than 90 per cent. by certain sulfa drugs as we have proved. A preventive vaccine in plague would help, but the need is not so immediate because the sulfa drugs give a fair control. More than that, the plague bacillus has a capsule or covering which is difficult to remove and the electrophoretic fractionations of the organism in order to find the protein fraction of the bacillus which will give the greatest immunity in a vaccine is very difficult.

Cholera, on the other hand, is a disease which often kills overnight and no treatment is effective. It is obvious therefore that a preventive and not a treatment is required.

V.23
1945

Cholera is endemic in the Far East, India, China, the Phillipine Islands, Indo-China and Thailand. The only statistics available are from British India. In ten years to 1916, the deaths never fell below 300,000 annually and in the twenty years to 1924 there were eight million deaths from cholera. In the ten years to 1934, there were two and a half million deaths in British India alone. It should be remembered that British India is not all of India and that the statistics of the other parts of the Orient if available would multiply these figures.

The statistics since the war are not available but cholera was unusually severe in 1938 in India, China and the Far East and the epidemic was revived in 1943, no doubt aided by refugees, poor sanitation and ease of communications. In China the disease was more than severe in 1938 and no doubt is continuing. The disease is most prevalent in the Provinces of Hunan and Hupet, not far from Chungking. There have been epidemics in Europe, in Bulgaria, Greece, Turkey, Mesopotamia and Russia.

We began to study the cholera organism which is a vibrio, not a bacterium, from the point of view of fractionating its parts by means of supersonic shaking, high speed centrifugation and separation of minute fractions by means of the Tiselius electrophoretic apparatus. We were not so successful in this because we found that the real need was a greater growth of the organism in cultures. This was achieved by altering the medium and controlling the pH as well as supplying constant aeration. The medium is entirely synthetic and requires a

minimum of equipment and no special technical skill. The entire process may be carried out by any laboratory technician, so like most good discoveries it is simple in application.

A suitable strain of cholera is carried in stock cultures on agar slants. An inoculum or seeding on the BRF medium is prepared in a small flask (Figs. 6 to 10) and incubated for 24 hours. The entire first culture is used as an inoculum for the larger 13-liter batch: this latter is subject to continuous aeration with air to which CO_2 has been added. The growth is complete in about 24 hours when the culture is sterilized by phenylmercuric acetate and distributed into suitable containers.

That is all there is to it. The entire culture, 65,000 doses, after suitable sterility tests may be used directly as vaccine without further manipulation and may be produced in 3 days.

The BRF Direct Cholera Vaccine has the advantage of being grown on artificial medium in a liquid and so is a liquid culture rather than a

FIG. 6. Experimental flask containing 1 liter of freshly inoculated medium.

FIG. 7. Thirteen-liter culture of freshly inoculated BRF medium.

FIG. 8. Completed thirteen-liter culture in incubator.

FIG. 9. Addition of phenylmercuric acetate.

FIG. 10. Ingredients of BRF medium.

suspension of organisms; the whole organism with all its immunizing properties is present in the vaccine. In addition it immunizes with a single dose, at least for the one year that we have watched it.

The old method had cholera grown upon solid media where the growth was very sparse and had to be scraped off with the detritus and collected, washed and sterilized. The whole process was inefficient and

cumbrous and gave great chances for reactive substances to be carried over in the scraping and cleansing from the solid organic media used in the growth. Three injections were required. The process was cumbrous, filled with loopholes and expensive. It requires a factory set-up.

The BRF vaccine can be grown anywhere with little technical skill and small laboratory equipment in four or five days. It can be set up near an epidemic and produced at will rather than having to send to a central depot for limited supplies of vaccine probably long in storage.

The one shot immunity is very helpful because few natives wish to return with a sore arm for two or more injections. The potency of the vaccine is so great that the very small dose compared to the older vaccine can be given and so a smaller quantity of vaccine need be transported and stored.

The new method of cultivation has given such strong growth in cultures that we now have on hand 30 or more grammes of dried cholera vibrio, many times more than ever existed before where there was occasionally a milligram or two. This gives a possibility not before possible for the study of the chemical properties and toxins of the vibrio itself. We have recently got a line on a toxin of the vibrio which may be the essential poison of cholera, but this is so new with us yet that further work must be required.

So in these war years, our work, while directed to war efforts, has followed our initial premise, that it should be for the benefit of mankind.

I hope that when next year this report once more comes around that I shall be able to give it to you and that I may give it with only peace-time restrictions.

Atchison Storage Well Insulated.—Refrigeration engineers will be watching America's venture in underground food storage in the limestone mine near Atchison, Kans., which was opened for business recently as one of the biggest cold storage warehouses (or warecaves) in the world.

While cooling equipment is being installed, the mine is being operated as cooler storage—not freezer storage—at its natural temperature of 50 to 55 degrees F. The natural effectiveness of the insulation provided by the earth and rock over and around the mine is clear. This mine stays cool at the end of the hot Kansas summer. Cooling equipment is planned to reduce the temperature to the cold storage point of just about freezing. However, the engineers estimate that, because of the natural insulation, a unit of cooling will prove more efficient in the mine than in a building where refrigeration has to be planned to take care of the heat that enters even the best insulated buildings.

Fans or blowers are being installed for distribution of the air chilled by artificial refrigeration. The engineers are also considering the possibility of using this equipment in cold winter weather to circulate outside air into the "cool storage" areas to make them still cooler for the spring and summer storage season. In a sense, they say, the natural insulating conditions of the mine would then be giving them a chance to store not only food, but also to store winter cold for use next year.

This mine is of the type commonly known as a gallery quarry. Galleries running into a hill have an average height of 14 feet. The interior is polygon shaped and a line enclosing the galleries would measure more than a mile. This provides between 7 and 8 million cubic feet of storage space, and it is estimated that buildings to provide that total of storage would cost about $15,000,000—even if wartime conditions allowed time, material and refrigeration machinery to equip them.

R. H. O.

V.23
1945

SENSITIVITY DISTRIBUTION AMONG THE GRAINS OF PHOTOGRAPHIC EMULSIONS.

BY

A. P. H. TRIVELLI.

Communication No. 983 from the Kodak Research Laboratories.

INTRODUCTION.

A few years ago in a paper entitled "Uniform Representation of the Characteristic Curves of Pure Silver Bromide Emulsions, Unsensitized and Sensitized," Dr. Ludwik Silberstein [1] stated: "Now, as has been remarked by Mr. A. P. H. Trivelli, of these Laboratories, there are good reasons to suppose that the grains of an emulsion are differently affected by the sensitizing process and that in this respect, the whole emulsion might, perhaps, be considered summarily as consisting of two groups of grains or of two components, each behaving sensitometrically as the original emulsion, but endowed with different parameter values."

The experimental evidence which led to this conclusion for many photographic emulsions will be described and discussed in this paper. The investigation was made by applying Silberstein's quantum theory [2] in its accurate form as derived from Poisson's law to the analysis of the shapes of the characteristic curves. The general equation used in this theory holds in its simple form only for a single sensitivity distribution among the grains.

FOG CORRECTION.

An investigation of the shapes of characteristic curves requires the highest degree of accuracy obtainable in emulsion making and in sensitometric processing. Useful characteristic curves for this work have been obtained through the co-operation of the Physics Department of these Laboratories. The curves, however, required correction for fog. The author used a proportionality equation, suggested by Silberstein, having the following form:

$$\phi_c = \phi \left(\frac{D_{max} - D_c}{D_{max}} \right), \qquad (1)$$

in which D_{max} is the maximum density produced by the developer at the development time chosen, which gives the fog density ϕ; ϕ_c is the fog correction, that is, the density to be subtracted from the observed

[1] *J. Opt. Soc. Amer.*, **32**, 474-485, August, 1942.

[2] *Phil. Mag.*, **44**, 257 (1922); **45**, 1062 (1923); [7] **5**, 464 (1928). *J. Opt. Soc. Amer.*, **28**, 441 (1938); **31**, 343 (1941).

density, D_{obs}; D_c is the fog-corrected density, so that

$$D_c = D_{obs} - \phi_c,$$

which gives

$$\phi_c = \phi \frac{D_{max} - D_{obs} + \phi_c}{D_{max}},$$

$$\phi_c \left(1 - \frac{\phi}{D_{max}} \right) = \phi \left(1 - \frac{D_{obs}}{D_{max}} \right);$$

whence

$$\phi_c = \phi \left(\frac{D_{max} - D_{obs}}{D_{max} - \phi} \right).$$

If ϕ is a small fraction of D_{max}, φ_c can be disregarded.

ROTATIONALLY SYMMETRICAL AND ASYMMETRICAL CHARACTERISTIC CURVES.

The fog-corrected characteristic curve can have, in general, two different shapes:

(a) a rotationally symmetrical one, giving density, $\bar{D}$, at the inflection point:

$$\bar{D} = \tfrac{1}{2} D_{max},$$

and

(b) a rotationally asymmetrical one, giving a density, $\bar{D}$, at the inflection point:

$$\bar{D} \neq \tfrac{1}{2} D_{max}.$$

The rotationally symmetrical curve is characterized by the fact that the part from D_{zero} to $\bar{D}$ can be rotated around the inflection point until it coincides completely with the part from $\bar{D}$ to D_{max}. This is not the case with the rotationally asymmetrical characteristic curve. For the sake of convenience, the word "rotationally" will be omitted in the rest of this discussion, and the shapes of the characteristic curves will be differentiated by the adjectives, symmetrical and asymmetrical.

The symmetrical characteristic curve from D_{zero} to D_{max} can be represented by the equation:

$$\frac{D}{D_{max}} = \frac{y^2(3 + y)}{(1 + y)^3}, \tag{2}$$

in which

$$y = n\bar{a}\epsilon. \tag{3}$$

In this equation, n is the exposure, measured in quanta, $\bar{a}$ is the average grain size in μ^2, and ϵ is the intrinsic sensitivity measured by

$$\epsilon = \frac{hc}{\lambda E_1 \bar{a}}, \tag{4}$$

in which h is Planck's constant, c is the velocity of light, λ is the wave-

length of the radiation, E_1 is the exposure at the inflection density, and $\bar{a}$ is the average grain size, measured by its projective area in μ^2. The product $hc = 1.9627 \cdot 10^{-16}$ ergs per cm.^{2}.

Such symmetrical curves were obtained repeatedly, but not always with an unsensitized pure silver bromide emulsion, coated on film. Small differences in the making of the emulsions and in the coating of the films are sufficient to produce asymmetrical instead of symmetrical characteristic curves.

If, however, a pure silver bromide emulsion, giving a symmetrical characteristic curve, is sensitized with a sulfur-containing sensitizer, then, as far as experimental data are available, the symmetrical characteristic curve always becomes asymmetrical and Equation (2) no longer fits the data. The effect of such sensitizing can be studied by comparing the characteristic curves and their first derivatives before and after sensitizing the emulsions.

THE FIRST DERIVATIVES OF THE H AND D CURVES.

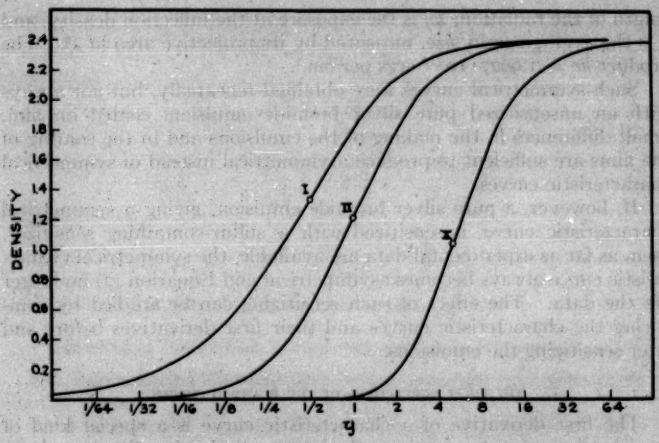
The first derivative of a characteristic curve is a special kind of sensitivity curve. It represents the increase in density of progressively exposed areas of the emulsion at a definite development time. It shows the changes in the sensitivity of the emulsion during the exposure.

From a symmetrical characteristic curve only a symmetrical first-derivative curve can be derived, and from an asymmetrical characteristic curve only an asymmetrical first-derivative curve can be constructed. The line of symmetry of the first-derivative curve is perpendicular to the log exposure axis passing through the maximum of the curve. This maximum indicates the location of the inflection point of the characteristic curve.

The construction of first-derivative curves is inaccurate. Therefore, only outstanding deviations from symmetrical first-derivative curves can be regarded as having experimental significance. However, two different kinds of asymmetrical characteristic curves can be differentiated empirically and their theoretical meaning must be investigated.

There are a number of asymmetrical characteristic curves which can be represented by different equations derived from Silberstein's modification of Poisson's law. In Figure 1, for instance, are three specific characteristic curves having, for convenience of comparison, the same maximum density, $D_{max} = 2.4$. They are derived from actual, observed characteristic curves by putting the densities $D = 2.4 \frac{D_{obs}}{D_{max}}$. Curve I follows the equation:

$$\frac{D}{D_{max}} = \frac{y(2+y)}{(1+y)^2}. \qquad (5)$$



A SYMMETRICAL AND TWO ASYMMETRICAL CHARACTERISTIC CURVES

FIG. 1.

V.23
1945

Curve II follows Equation (2), and Curve X follows the equation:

$$\frac{D}{D_{max}} = \frac{y^{10}(11+y)}{(1+y)^{11}}. \qquad (6)$$

All these curves fit their equations within the limit of experimental error. Curve II is symmetrical, but Curves I and X are asymmetrical. Their densities, D at E_1, are related to D_{max}, as shown in Table I.

TABLE I.

Curve	D/D_{max}
I	0.556
II	0.500
X	0.430

Curve I has a long toe with a flat, gradual slope and a short shoulder with a steeply sloping curve. Curve X has a short toe with a steeply sloping curve and a long shoulder with a flat curve.

If the first derivatives of these curves are constructed so that their perpendiculars on the exposure axis and passing through their maxima are superimposed, the curves of Figure 2 are obtained. Curve II is symmetrical. Curve I has a longer left side than right side, and Curve X has a longer right side than left side, if the line of symmetry of Curve II is taken as the dividing line between the two sides of the first-derivative curves.

The shapes of these three curves can be explained by a single probability distribution of sensitivity among the grains of these emulsions. Asymmetry alone, therefore, is not a criterion for distinguishing between a simple and a complex sensitivity distribution among the grains of an emulsion.

There are asymmetrical characteristic curves, however, produced by sulfur sensitizing which belong to a different type of asymmetrical curve. A few examples will make this clear. It has been found that an unsensitized silver bromide emulsion, the symmetrical characteristic curve of which is shown as Curve A, Figure 3, can be sensitized with an experimental sensitizing gelatin, giving an asymmetrical characteristic

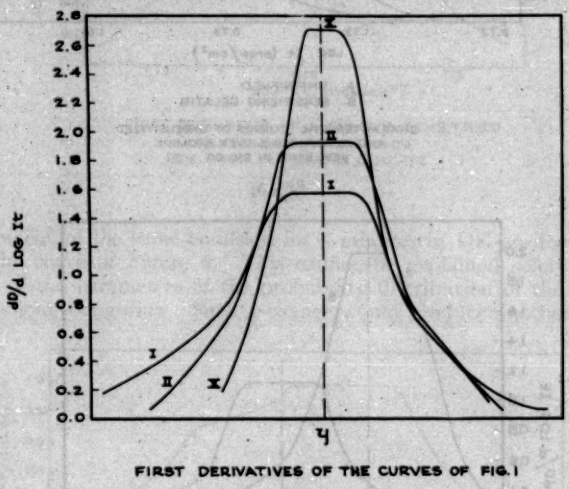
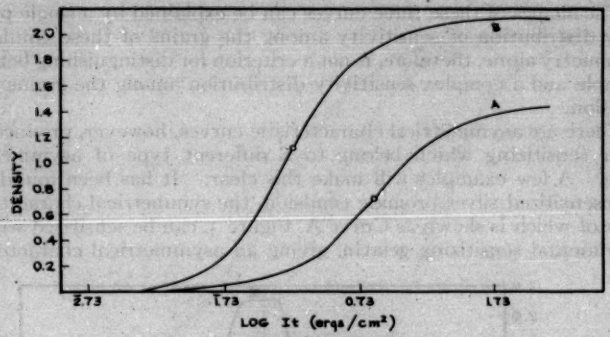


FIG. 2.

curve, *B*, which is shown in the same figure. Curves A and B were both obtained with the same exposure and with the same development time, 5 minutes in DK-50 developer at 68° F. Both emulsions were coated on film in the same way and at the same thickness.

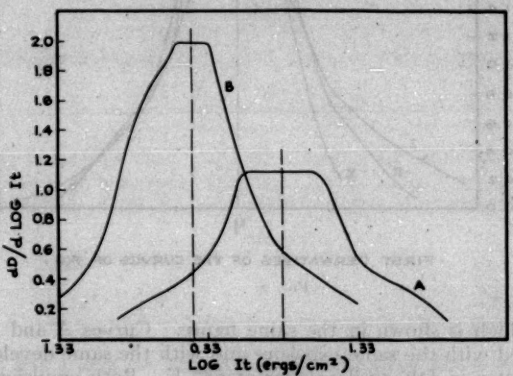
The first derivatives of these curves are shown in Figure 4. The dashed lines passing through their maxima are perpendicular to the Log *It* axis. For Curve A, the first derivative is symmetrical within the limits of experimental error, but that for Curve B is not. It is plain that the sensitizing action of the gelatin has changed the shape of the first-derivative curve so that it has apparently become quite irregularly asymmetrical. It is a different type of asymmetry from that shown in Figure 2.



A. UNFINISHED
B. SENSITIZING GELATIN

CHARACTERISTIC CURVES OF UNSENSITIZED AND SENSITIZED SILVER BROMIDE DEV. 5 MIN. IN DK-50

FIG. 3.



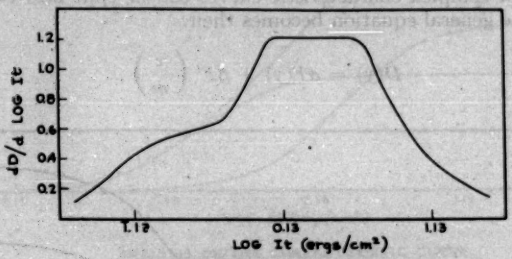
A. UNFINISHED
B. SENSITIZING GELATIN

FIRST DERIVATIVES OF THE CHARACTERISTIC CURVES OF FIGURE 3 DEV. 5 MIN. IN DK-50

FIG. 4.

Inasmuch as the sensitizing action of the gelatin may be ascribed to sulfur compounds, we may conclude that the sensitivity distribution among the grains has been changed by the sulfur sensitizing of the

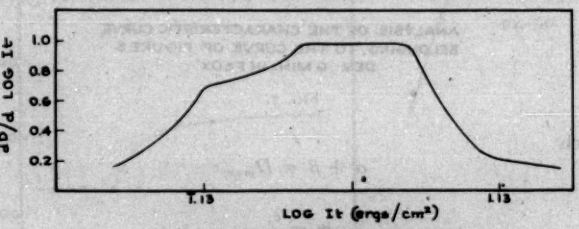
emulsion. The same thing occurs in a different way with other sulfur compounds. For instance, in Figures 5 and 6 are shown the first-derivative curves of a differently sensitized emulsion. Development for 6 minutes in ferrous oxalate developer gives the curve of Figure 5, and



FIRST DERIVATIVE OF A SULFUR-SENSITIZED SILVER BROMIDE EMULSION DEV. 6 MIN. IN FERROUS OXALATE

FIG. 5.

development of the same emulsion for 5 minutes in DK-50 developer gives the curve of Figure 6. This cannot be explained solely by a change of the parameters of the probability distribution of the sensitivity among the grains. Such a change would produce another sym-



FIRST DERIVATIVE OF A SULFUR-SENSITIZED SILVER BROMIDE EMULSION DEV. 5 MIN. IN DK-50

FIG. 6.

metrical curve or an asymmetrical curve of the type shown in Figures 1 and 2. The sulfur sensitizing has changed the sensitivity distribution among the grains from a relatively simple to a relatively complex one. This introduces a distinction between simple and complex characteristic curves.

SIMPLE AND COMPLEX CHARACTERISTIC CURVES.

The author calls a characteristic curve simple if it can be represented by a single equation derived by Silberstein from Poisson's law. It has been found empirically that in all cases so far investigated, the majority of complex characteristic curves can be split into two simple ones. The general equation becomes then:

$$D(y) = \alpha F(y) + \beta F'\left(\frac{y}{m}\right), \qquad (7)$$

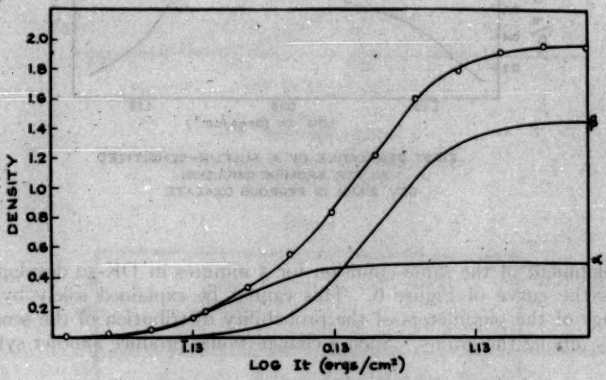


FIG. 7.

in which

$$\alpha + \beta = D_{max},$$

and

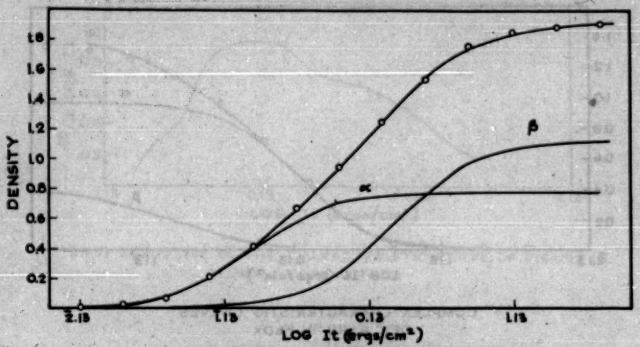
$$m = \frac{\epsilon_1}{\epsilon_2}. \qquad (8)$$

In Equation (8), ϵ_1 and ϵ_2 are the intrinsic sensitivities of the components.[3]

The author has taken as an example an analysis of the characteristic curves, the first derivatives of which are shown in Figures 5 and 6. The curves themselves with their components are given in Figures 7 and 8. The small circles represent the densities calculated from the

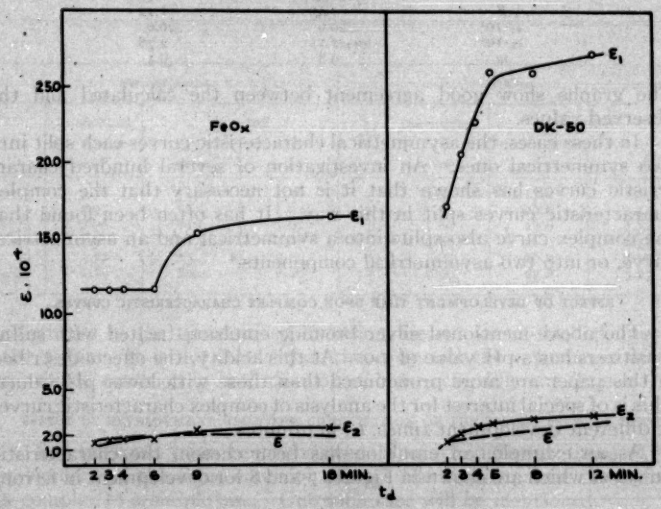
[3] A separate paper with Dr. Silberstein will discuss the analysis of these complex curves more extensively.

V.23
1945



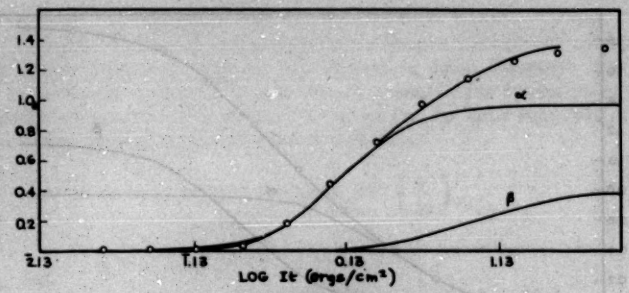
ANALYSIS OF THE CHARACTERISTIC CURVE
BELONGING TO THE CURVE OF FIGURE 6
DEV. 5 MIN. IN DK-50

FIG. 8.



ε₁/t_d AND ε₂/t_d CURVES

FIG. 9.



COMPLEX CHARACTERISTIC CURVES
DEV. 6 MIN. IN FeOx

FIG. 10.

equations of the components of which the parameters are given in Table II ($\bar{a} = 0.82\mu^2$).

TABLE II.

Constant	Fe Ox	DK-50
α	0.50	0.78
β	1.45	1.12
$\epsilon_1 \cdot 10^4$	20.6	26.0
$\epsilon_2 \cdot 10^4$	2.11	2.78
m	9.8	9.4

The graphs show good agreement between the calculated and the observed values.

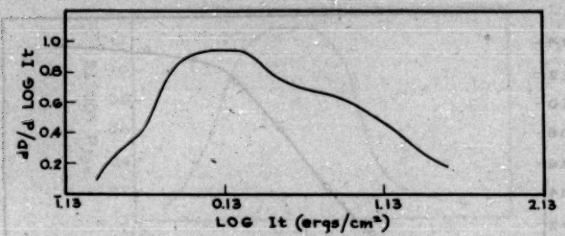
In these cases, the asymmetrical characteristic curves each split into two symmetrical ones. An investigation of several hundred characteristic curves has shown that it is not necessary that the complex characteristic curves split in this way. It has often been found that the complex curve also splits into a symmetrical and an asymmetrical curve, or into two asymmetrical components.[4]

EFFECT OF DEVELOPMENT TIME UPON COMPLEX CHARACTERISTIC CURVES.

The above-mentioned silver bromide emulsion treated with sulfur sensitizers has a pH value of 7.0. At this acidity, the effects described in this paper are more pronounced than those with lower pH values. This is of special interest for the analysis of complex characteristic curves at different development times, t_d, in minutes.

As an example, an emulsion has been chosen, the characteristic curves of which are shown in Figures 7 and 8 for development in ferrous

[4] One case has been found in which a symmetrical curve had to be split into two other symmetrical ones. A few cases have been found in which the first derivative of the characteristic curve showed three maxima. This curve had to be split into three symmetrical ones.



FIRST DERIVATIVE OF THE CHARACTERISTIC CURVE OF FIGURE 10
DEV. 6 MIN. IN FeOx

FIG. 11.

oxalate and DK-50, respectively. If the development in ferrous oxalate is extended from 2 to 18 minutes, and that in DK-50 from 2 to 12 minutes, ϵ_1/t_d- and ϵ_2/t_d-curves can be obtained for the components of the complex characteristic curves. These can be compared with those of the ϵ/t_d-curves of the unsensitized emulsion. The calculated values are given in Table III. The curves are plotted in Figure 9. The

TABLE III.

ϵ/t_d-curves

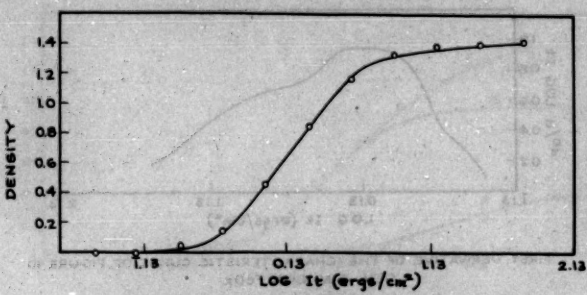
Ferrous Oxalate				DK-50			
t_d	Unsensitized	Sensitized		t_d	Unsensitized	Sensitized	
	$\epsilon \cdot 10^4$	$\epsilon_1 \cdot 10^4$	$\epsilon_2 \cdot 10^4$		$\epsilon \cdot 10^4$	$\epsilon_1 \cdot 10^4$	$\epsilon_2 \cdot 10^4$
2	1.76	11.6	1.40	2	1.50	17.0	1.44
3	1.97	11.6	1.62	3	1.64	20.6	2.11
4	2.06	11.6	1.62	4	1.80	22.6	2.54
6	2.11	11.6	1.62	5	1.88	26.0	2.78
9	1.72	15.3	2.29	8	2.27	26.0	3.05
18	1.72	16.4	2.46	12	2.99	27.2	3.27

ϵ/t_d-curves of the unsensitized emulsion are drawn as dashed lines in the graph. It is noticeable that the ϵ_1/t_d- and the ϵ_2/t_d-curves of the sensitized emulsion in both developers have very different shapes.

EFFECT OF DEVELOPMENT UPON THE CONSTITUTION OF THE CHARACTERISTIC CURVE.

Several cases have been observed in which different times of development of the same emulsion change the characteristic curve from a complex to a simple one. One such case will be mentioned.

In Figure 10 is given the characteristic curve of an emulsion developed for 6 minutes in ferrous oxalate. In Figure 11 is shown the



SIMPLE CHARACTERISTIC CURVE OF THE SAME EMULSION
DEV. 5 MIN. IN DK-50

FIG. 12.

first derivative of this characteristic curve. It shows an asymmetry, which indicates a complex sensitivity distribution among the grains. The characteristic curve can be split into two curves, the first one of which follows the equation:

$$\frac{D}{\alpha} = \frac{y^4(5+y)}{(1+y)^5}, \tag{9}$$

and the other one the equation:

$$\frac{D}{\beta} = \frac{y^2(3+y)}{(1+y)^3}. \tag{2a}$$

The parameters of the complex characteristic curve are those given in Table IV ($\bar{a} = 0.82\mu^2$).

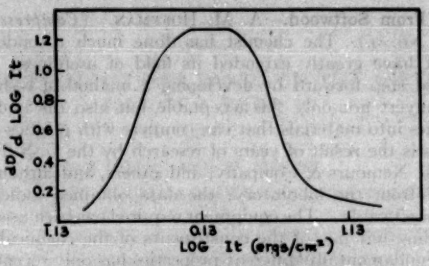
TABLE IV.

α	β	$a_1 \cdot 10^4$	$a_2 \cdot 10^4$	m
0.98	0.39	9.92	0.66	15.0

The densities calculated by Equation (6) are plotted as small circles in Figure 10, showing an agreement between the observed and calculated densities within the limits of experimental error. If, however, this same emulsion is developed for 5 minutes in DK-50 developer, a characteristic curve is obtained, shown in Figure 12, having an asymmetrical first derivative of the shape as given in Figure 13. This curve is a simple characteristic curve, in accordance with the equation:

$$\frac{D}{D_{max}} = \frac{y^3(4+y)}{(1+y)^4}, \tag{10}$$

V.23
1945



FIRST DERIVATIVE OF THE CHARACTERISTIC CURVE OF FIGURE 12
DEV. 5 MIN. IN DK-50

FIG. 13.

with an intrinsic sensitivity

$$\epsilon \cdot 10^4 = 5.84.$$

The calculated densities are plotted as small circles in Figure 12, indicating an agreement between the observed and the calculated densities within the limits of experimental error.

SUMMARY.

By applying Dr. Ludwik Silberstein's quantum theory of exposure to the distribution of sensitivity in photographic emulsions of pure silver bromide, it has been shown that:

1. The use of the first derivatives of the fog-corrected characteristic curves makes it possible to study the sensitivity distribution among the grains of an emulsion.

2. Fog-corrected characteristic curves with their first derivatives can be divided empirically into two groups of curves: symmetrical and asymmetrical. These curves can be divided into simple and complex characteristic curves, depending upon whether there are one or two different types of sensitivity distribution among the grains.

3. An emulsion can give either a simple or a complex characteristic curve, depending upon the development.

Hardwood From Softwood.—A. M. HOFFMAN. (*Compressed Air Magazine*, Vol. 49, No. 9.) The chemist has done much to endow wood with properties that have greatly extended its field of usefulness. Now he has taken a marked step forward by developing a method of resinification that promises to convert not only the acceptable but also the undesirable, fast-growing varieties into materials that can compete with plastics and metal.

The process is the result of years of research by the U. S. Forest Service, E. I. duPont de Nemours & Company, and others, and although it has but lately emerged from the laboratory, the data obtained indicate that it is commercially practicable. The equipment required has been used in creosoting and impregnating, but one of the constituents of the chemical by which the wood is given fundamentally different properties has only recently been made available on an industrial scale. It is dimethylolurea, which is combined with urea to form methylolurea.

The so-called "full-cell" or vacuum pressure method of impregnation is considered most suitable. Before treatment the wood is dried well below its fiber-saturation point so that the flow of the solution and its diffusion throughout the cell walls will not be impeded. Cut as nearly as possible to finished form, the material goes into the pressure chamber. Withdrawal of air from the cylinder is effected by a steam jet ejector or a vacuum pump, which also serves to draw the chemical from a nearby mixing tank into the cylinder through a bottom opening. Enough methylolurea solution is introduced to allow for absorption and to keep the contents covered throughout the treatment period. At this stage of the process, suction is broken and compressed air is applied at a pressure not exceeding 100 pounds per square inch for most purposes and for periods from 10 to 50 minutes, depending on the desired depth of penetration. With impregnation finished, the left-over chemical is forced back into the mixing tank by compressed air for reuse; pressure in the system is vented; and the wood is removed from the chamber for drying.

According to J. F. T. Berliner of the duPont Company, the methylolurea is converted into resin by the natural acids present in the wood. It enters as a water-soluble, uncondensed material; but the wood acids, plus heat such as is applied in normal kiln drying, or air seasoning for the customary length of time, change it into an insoluble but fusible resin. Over a period of time, or if subjected to elevated temperatures for a short while, the resin is converted into the infusible state. When the wood is molded under pressure and at a temperature of 240 deg. F. or higher the resin will melt and flow and become infusible. In consequence, the finished product shows a markedly reduced tendency to dimensional changes when exposed to water or moisture at moderate temperatures.

Wood treated by the new process may be compressed to any desired specific gravity up to about 1.4, producing a hard, strong, close-grained product that requires no filling.

R. H. O.

IMPACT DETERMINATIONS BASED ON THE ARRESTED FALL OF A BODY.

BY

L. F. DYTRT AND W. SPECHT,

Manufacturing and Engineering Divisions, General Electric Company, Philadelphia, Pa.

The need has grown, most notably in recent years, to ascertain the impact capacity of various products, particularly those for use aboard ships and in battle areas. Consequently, several testing arrangements for demonstrating this capacity have been devised. Most of them, in essence, are but refined hammering mechanisms; that is, they establish definite impacts in test specimens by causing them to be struck while at rest by moving masses with known amounts of energy. But such percussions manifestly create impact conditions not only in the body struck, but in the striking mass as well. Advantage of this last fact is taken in the arrangement described. It utilizes the principle of impact production in a freely falling body by sudden arrest thereof. Though each of these testing systems has been developed during late years none, considered from a basic standpoint and without regard to detail, is of recent origin. The several systems long have been objects of shock investigations.

Adaptabilities of the arrangements vary in practice. The particular arrangement being taken up, for example, embodies features which make it especially well suited for the determination of impact strengths of small and light-weight products. Presumably it has been adopted for that reason by the ASA as American War Standard C39.3–1943, this relating to the shock testing of electrical indicating instruments. While less easily adapted to the testing of equipments weighing much over 100 pounds the arrangement, because of its simplicity, is resorted to on occasion in even those cases.

Performance of tests with it is resolvable into two main parts. First, the product undergoing investigation is subjected to varying impacts by allowing it to fall through preselected vertical heights upon an arresting member. Determining such heights obviously is the object of the test. This object, for instance, might be merely to learn whether a given product has the capacity to withstand safely a specified impact or, again, it might be to ascertain the minimum, product-disabling impact. Secondly, there is the calculation of impact values. Of course, where repetitive testing of identical products in a specific test make-up is to be carried out, it is possible to prepare a graph showing impact values as a function of the height the product is allowed to fall, and by this means to avoid the calculation of individual impacts.

Essential elements of the testing arrangement are diagrammed in Fig. 1. These include a rigid base; an elastic, restraint-producing unit; an engaging head and a coupling stem, both being of a rather inelastic

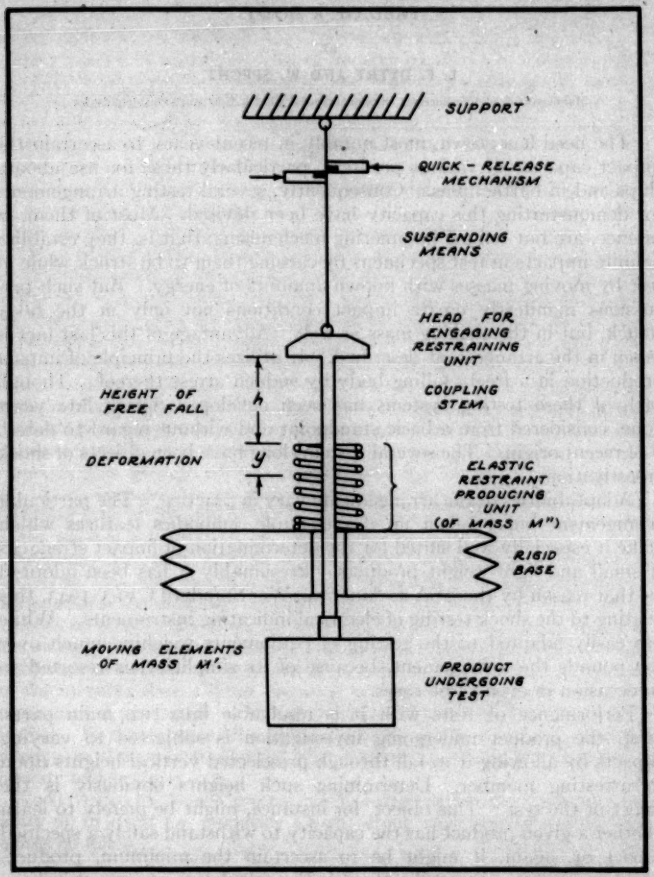


FIG. 1. Simplified form of the testing arrangement and parts comprising it.

nature and serving to effect an energy transference between the product undergoing test and the unit for producing restraint; a means for supporting the test specimen and parts coupled thereto above a deflection

reference level; and a quick-release mechanism. In a practical apparatus the restraint-producing unit normally would be a spring of appropriate deflection characteristics. For the supporting means and quick-release mechanism, on the other hand, various devices might be provided: a steel wire and suitable shears, respectively, constituted these in the make-up shown in Fig. 2.

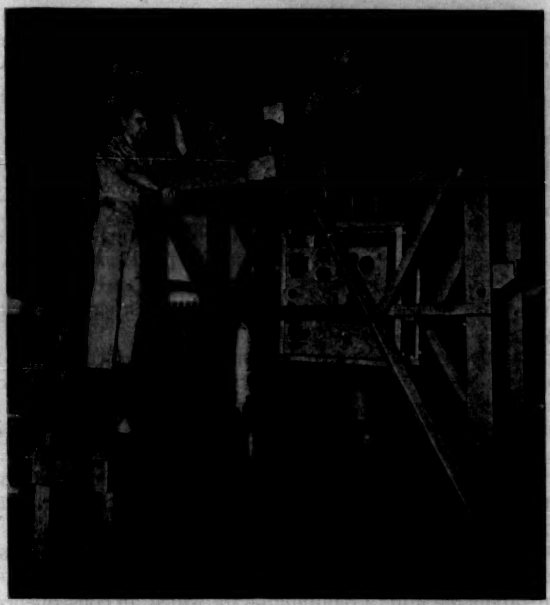


FIG. 2. (Photograph 839490.) Improvised shock test make-up with a partially dismantled, a-c generator control cabinet in position to be given lateral impacts.

Comprising the initial or experimental phase of the test are the following steps: first, the product to be tested is raised to a selected height above the reference level adopted, this being in Fig. 1 the upper face of the restraint-producing unit; second, the specimen is released suddenly from its elevated position so that it drops as a freely falling body; and third, it is subjected to abrupt retardation in its fall shortly after coming into contact with the restraining element. Since this is an elastic member it will cause the test specimen to rebound and, in the absence of preventive measures, subsequently to describe oscillatory

movements until the damping forces of the make-up bring about static equilibrium. To preclude the possibility of such oscillations occurring, each of which would evidently produce new impact conditions, provisions are usually made to catch the test specimen after its first rebound.

Because impacts are not measured in the arrangement under comment but are evaluated by computation, it is important that a number of theoretical considerations be closely approached. Failure to attend to them may lead to serious errors in final results. One such consideration, for example, relates to the almost instantaneous release of the object being tested from its suspended position. Any stretching of the means of suspension, or similarly effective phenomenon just prior to the release of the object, would tend to prevent it from attaining the speed in falling which is presupposed by theory. Another disturbing influence, one acting similarly to that just described, would be any friction that could interfere with a free and unrestricted drop by the object after its release. Still another consideration is the need for limitation of stresses set up in the restraint-producing unit to values below proportional elastic limits of the material used therein. From these few illustrations it is easy to infer what testing precautions the underlying theory of the arrangement imposes.

Impact effects on any given test specimen are determined for the most part by visual inspection and by repeated trials of it in circumstances which disclose its capacity or incapacity to perform normal functions. Such steps, however, even though essential to regular testing, are no part of the test proper as it is being treated here.

To render clear the second phase of the test arrangement, namely, calculation of impact values, there is entailed initially an analysis of those quantities that give rise to forces in the test system. These quantities, as may be discerned in Fig. 1, are: The mass, M', of the test specimen and parts rigidly attached thereto; the mass, M'', of the restraint-producing unit; a damping factor which, in consequence of its generally complex nature and its being made by structural means as small as practicable, is neglected; and the deflection rate or spring constant, k, of the restraining element. If, as is here assumed, this element is a coiled spring, only about one-third of its mass will appear to be effective in determining the period of natural vibration of the system. This fact is demonstrated in most standard textbooks on vibration phenomena. Thus the apparent mass, M, in motion is

$$M = M' + \frac{M''}{3}. \qquad (1)$$

With this established it is now possible to formulate the equation for force equilibrium.

Let it be supposed in this connection that the object undergoing test has completed its journey as a freely falling body and hence has established contact with the restraint-producing unit. Thereupon the object and unit together will develop an inertial or reversed effective force of amount:

$$M\frac{d^2y}{dt^2},$$

where d^2y/dt^2 is the acceleration or deceleration at any instant. Accordingly as deceleration or acceleration is taking place this force acts, respectively, in coöperation with the weight, W, of the test specimen or oppositely thereto. In any event the difference between these two quantities, allowing appropriate algebraic signs to indicate accelerations and decelerations, will be equal practically to the reacting force, ky, developed by the restraining member when deformed a distance y. Mathematically this instantaneous equilibrium state may be represented by the expression

$$M\frac{d^2y}{dt^2} + ky = W. \tag{2}$$

The complete solution of equation (2) for the variable y is

$$y = A\cos\sqrt{\frac{k}{M}}\,t + B\sin\sqrt{\frac{k}{M}}\,t + \frac{W}{k}. \tag{3}$$

Here t signifies the time in seconds after the falling body has come into contact with the restraining member; A and B are integration constants the values of which depend upon terminal conditions of displacement and velocity within the test system; and the other factors have the meanings previously assigned to them.

Since it is necessary to know the instantaneous velocity, v, of the test specimen following its engagement with the restraining unit in order to evaluate the constants A and B, and, further, since this velocity is expressed by the first derivative of equation (3), that derivative is taken next. Thus

$$\frac{dy}{dt} = v = -A\sqrt{\frac{k}{M}}\sin\sqrt{\frac{k}{M}}\,t + B\sqrt{\frac{k}{M}}\cos\sqrt{\frac{k}{M}}\,t. \tag{4}$$

Substitution now in equations (3) and (4) of the boundary conditions, namely, that at time $t = 0$, the deformation $y = 0$ and, coincidentally, $v = \sqrt{2gh}$, where g signifies the acceleration of gravity and h, the height through which the object being tested falls freely, reveals

$$A = -\frac{W}{k} \quad \text{and} \quad B = \sqrt{\frac{2ghM}{k}}.$$

Replacement of A and B in equation (3) by the values just found for these symbols yields

$$y = \sqrt{\frac{2ghM}{k}} \sin \sqrt{\frac{k}{M}}\, t - \frac{W}{k} \cos \sqrt{\frac{k}{M}}\, t + \frac{W}{k}. \tag{5}$$

From equation (5) it is possible, by taking two derivatives with respect to the argument t, to find the acceleration, a, of the test specimen at any instant. That, in turn, opens the way for determination of relative impacts. Set down, the second derivative is

$$\frac{d^2y}{dt^2} = a = -\sqrt{\frac{2ghk}{M}} \sin \sqrt{\frac{k}{M}}\, t + \frac{W}{M} \cos \sqrt{\frac{k}{M}}\, t.$$

By rewriting this as a function of two angles a more simplified expression results. Accordingly

$$a = g\sqrt{\frac{2hk}{Mg} + \left[\frac{W}{Mg}\right]^2} \cos\left[\sqrt{\frac{k}{M}}\, t + \phi\right]. \tag{6}$$

Here the angle ϕ is found from the relationship

$$\tan \phi = \frac{\sqrt{2ghkM}}{W}.$$

V.23
1945

Now relative impacts may be taken as the ratio of the maximum value of the acceleration, a, to the acceleration of gravity, g, this ratio being denoted by the letter G. Since for the test system under consideration the maximum value of acceleration, a, is given by the modulus of the harmonic term, this term alone having a peak value of unity, it is possible to write

$$\frac{a}{g} = G = \sqrt{\frac{2hk}{Mg} + \left[\frac{W}{Mg}\right]^2}. \tag{7}$$

Through use of equation (7), finally, the work included in the second phase of the testing arrangement can be completed.

All that the second phase requires is that appropriate substitutions be made for the various quantities in this expression and that the mathematical processes indicated be performed. Computation of G, the relative impact, is, in brief, the purpose of this phase of the test.

The significance of this term is rather apparent. Being the ratio of a circumstantially-imposed acceleration to the acceleration of gravity G denotes the number of times the impact force acting on the test specimen is greater than the normal weight of the specimen. Thus if an object has a weight of 5.0 pounds and it is tested under circumstances which cause the ratio G to be 8.0, then the object momentarily is acted upon by 40.0 pounds. Connoted by the term, furthermore, as a result of such force applications generally attaining values productive of

limiting or rupturing stresses is the impact strength of a body. To be sure this is not always the case but where it is desirable to define minimum impact strengths, as in specifications, or where ultimate strengths are to be compared, as in various tests, there the ratio G in this special sense is a useful strength index.

A more simplified analysis of the impact phenomenon, though one that is slightly less accurate than the preceding, may be made from an energy standpoint. Essentials of the method of procedure therefrom are indeed outlined in the noted American War Standard, C39.3–1943. That analysis begins with the assumption that the maximum kinetic energy of both the object being tested and the connected parts becomes completely transformed into potential energy in the elastic restraining unit. Also supposed, and in the same connection, is the attainment by the falling object of its greatest velocity at the level where it just makes contact with the restraint-producing unit. This supposition, of course, is not quite true as may be perceived by inspection of equation (4) after substitution therein of the values of the constants A and B. Emanating at any rate from a correlation of these assumptions and use of symbolic notation is the following form of the aforementioned equality between kinetic energy and potential energy.

$$\tfrac{1}{2}M'v^2 = \tfrac{1}{2}kY^2. \tag{8}$$

Here Y is the maximum distance to which the restraining element is depressed.

From equation (8) it is found that

$$Y = v\sqrt{\frac{M'}{k}}. \tag{9}$$

Next, since v is being regarded as the maximum velocity, it is permissible to write the average velocity as Xv, where X signifies the ratio between the latter and former. In a test system where harmonic vibrations occur, for example, X would have the value 0.636.

If, now, the distance Y that the face of the restraining element deflects, as given by equation (9), is divided by the average velocity of the test specimen while it is in contact with this element the time, T, wherein the specimen is brought to rest is found. That is

$$T = \frac{Y}{Xv} = \frac{1}{X}\sqrt{\frac{M'}{k}}. \tag{10}$$

Over the interval of time T, furthermore, the velocity of the object being tested is presumed to vary from a maximum value, v, to a minimum of zero. Hence the average rate of change of velocity or average acceleration may be represented by the quotient

$$\frac{v}{T} = vX\sqrt{\frac{k}{M'}}. \tag{11}$$

From equation (11) the maximum acceleration may be readily determined if X is also regarded as the ratio of the average acceleration to the maximum. To obtain the latter acceleration it is merely necessary to divide that given in equation (11) by X. Such a step yields

$$a = v\sqrt{\frac{k}{M'}} = \sqrt{\frac{2ghk}{M'}}.$$

In order to obtain the relative impact, G, from the foregoing relationship, the dividend and divisor shown there under the radical sign are multiplied by the term g; the resultant divisor $M'g$, designating the weight of the test specimen and parts fastened thereto, is replaced by the equivalent symbol W; and a rearrangement of g is effected. By this means the following result is made to appear.

$$\frac{a}{g} = G = \sqrt{\frac{2hk}{W}}. \tag{12}$$

Though equations (7) and (12) differ somewhat yet they both give in most practical testing instances very nearly the same values for G. This follows from the fact that the quotient W/Mg occurring in equation (7) has a value of about unity whereas the factor to which it is added is ordinarily many times greater. Any difference noted in the values of G computed from the two equations, moreover, will be less in most cases than the combination of errors introduced by neglect of the damping factor and failure to realize in test all the theoretical conditions assumed.

To illustrate in a degree what has preceded an example is offered now which shows the manner in which relative impacts are evaluated. Assumed as data for the example are the following: A rigidly-built equipment is subjected to the impact conditions attending successively increasing heights of fall, and disablement of it is noted when its fall reaches 6.25 inches. It is desired to find the relative impact corresponding to this drop. The equipment and parts of the test make-up coupled thereto have a weight of 25.0 pounds, and the restraint-producing unit, a coiled spring, weighs 0.3 pound and has a deflection rate of 200 pounds per inch.

By means of formula (1) the weight, Mg, derivable from the apparent mass in motion, is

$$Mg = 25.0 + \frac{0.3}{3} = 25.1 \text{ pounds.}$$

Substitution next in equation (7) of this quantity together with the other pertinent data that were given leads to

$$G = \sqrt{\frac{(2)(6.25)(200)}{25.1} + \left[\frac{25.0}{25.1}\right]^2} = 10.0.$$

Had formula (12) instead of (7) been used in the calculation of G, a value that is the same as that given would have been obtained.

By means of equations (4), (5), and (6) the theoretical motion of

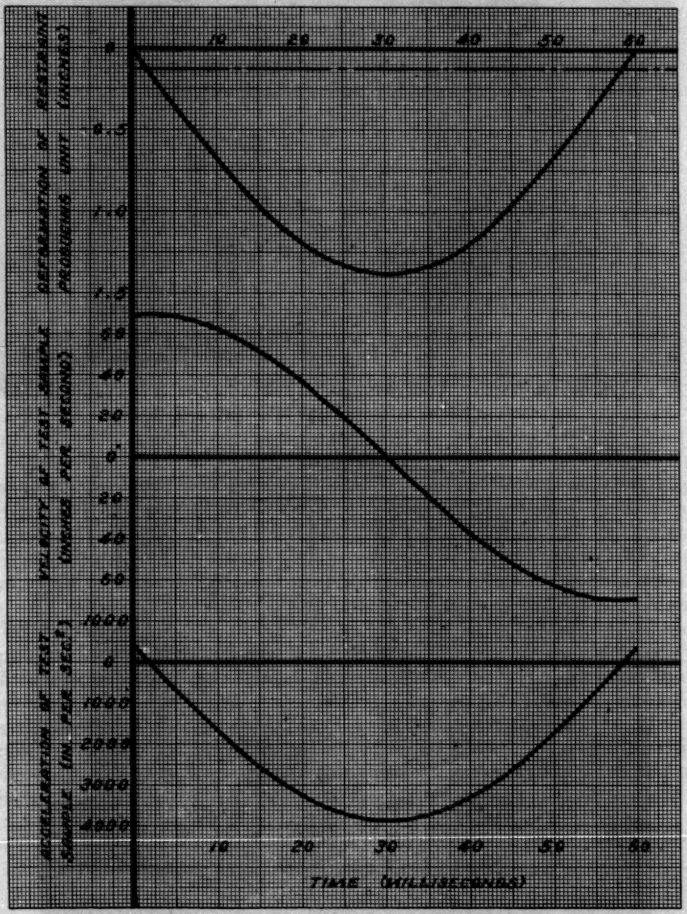


FIG. 3. Deformation, velocity and acceleration characteristics associated with a product undergoing test.

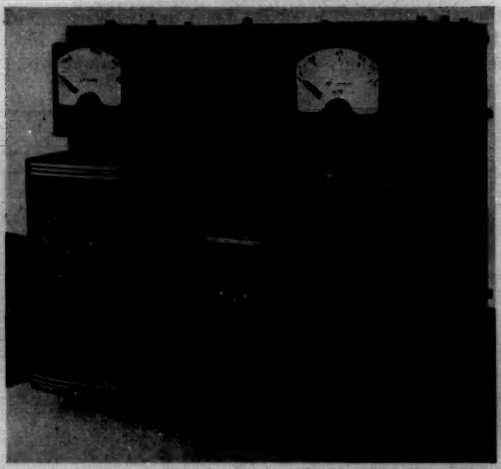


FIG. 4. (Photograph 352760.) View giving general frontal appearance of a nearly completed a-c generator control cabinet of type subjected to shock tests.

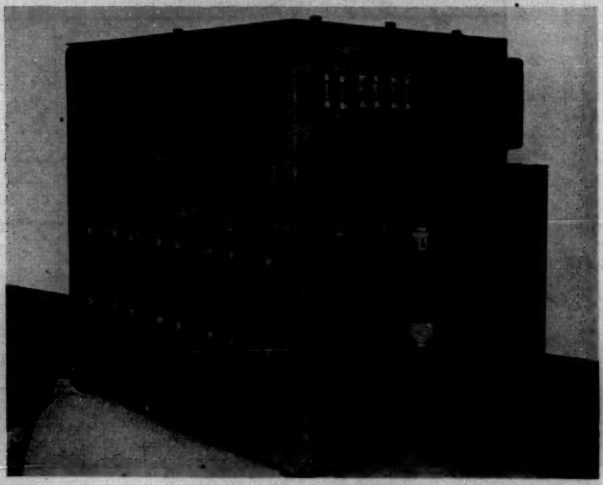


FIG. 5. (Photograph 352762.) View obtained from a position opposite one of rear corner uprights of the interior of a cabinet like the one tested.

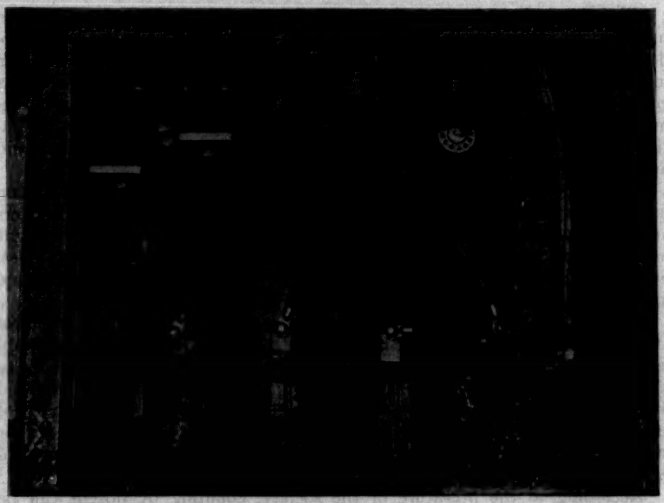


FIG. 6. (Photograph 352758.) Top view of interior of a generator control cabinet that is identical with the one used in the test make-up.

the test sample while in contact with the restraint-producing unit may be calculated. That was done and the results are presented in graphical form in Fig. 3. Shown at the top of this figure, for example, is a curve representing the instantaneous deformation of the restraint-producing unit, and, for comparative purposes, a broken line the level of which is below the reference axis by the static deflection that the test specimen would produce. Thus static and dynamic loading effects are rendered apparent. From the centrally located curve, a portrayal of the velocity of the test sample, may be discerned the previously mentioned fact that the velocity does not have its highest value at the instant contact is established between test sample and restraining unit. According to the trace given, the maximum velocity is reached a short time after this event. Lastly, the bottom curve, which represents the acceleration of the test sample, serves also to show how the impact varies with time.

The Duodecimal Society of America.—Announcement has recently been made of the formation of a new society for mathematical research, the Duodecimal Society of America, established as a voluntary, non-profit organization incorporated in New York state. The purpose of the Society, as stated in its constitution, is "to conduct research and education of the public in mathematical science, with particular relation to the use of Base Twelve in numeration, mathematics, weights and measures, and other branches of pure and applied science."

"We count by tens for no better reason than that we happen to have ten fingers," says F. Emerson Andrews, president of the Society. "Philosophers and mathematicians have long agreed that twelve is a better and more efficient number base than ten; its actual use has been advocated at various times, notably by Herbert Spencer, the British philosopher, and Isaac Pitman, inventor of an early system of shorthand.

"In the past few years, interest has grown in this old idea. A group of experimenters have been trying it out in both practical and theoretical problems—from helping the U. S. Army transport service figure cargo cubages to working with factorials. For some kinds of problems, the savings introduced by dozen-counting are no less than astonishing. The growing number of experimenters and the importance of their findings made a common center for information and further research a necessity, and the Duodecimal Society of America was formed."

According to the literature of the society, counting by dozens can be learned by anyone in the space of about half an hour. Two new numerals are required—*X* to represent ten, and *E* for eleven. Decimals are replaced by duodecimals, so that .*4* means four-twelfths, and is a perfect third—a fraction for which there is no accurate decimal equivalent.

Officers of the Society are George S. Terry of Hingham, Mass., chairman of the board; F. Emerson Andrews of New York City, president; F. Howard Seely of Oakland, Calif., vice-president; and Ralph H. Beard of New York City, secretary and treasurer. The Society is located at 20 Carlton Place, Staten Island 4, New York.

R. H. O.

NOTES FROM THE NATIONAL BUREAU OF STANDARDS.*

LONDON SCREW THREAD CONFERENCE.

On November 10, 1944, a meeting was held in the Social Security Building, under the chairmanship of W. L. Batt of the War Production Board, for the purpose of reporting to Federal agencies in Washington the results of the U. S.-Canadian Screw Thread Mission to London at which the member representing the Department of Commerce was Henry W. Bearce, and of discussing plans for continuing the work. The meeting was attended by representatives of the Departments of State, War, Navy, and Commerce, and of other interested groups. The results of the London Conference were reported by E. J. Bryant, chairman of the Mission, and copies of a printed report of the meeting were distributed. Speakers for each of the groups represented at the meeting expressed satisfaction with the progress so far made toward the adoption of a unified system of screw thread standards in the United States, Canada, and Great Britain, and expressed the hope that the work may be continued and the final objective attained.

A similar meeting was held in the Engineering Societies Auditorium in New York on November 16, 1944, at which a full report on the London Conference was given to the engineering societies and the public. The meeting was attended by several hundred persons and the report was well received. At an afternoon session on the same day reports were made by the individual members of the Mission, each member discussing in detail the special subjects for which he had been responsible at the Conference. Many pertinent questions were asked by members of the audience, and there was a full afternoon of interested discussion.

At a meeting on November 17, 1944, under the auspices of the Screw Thread Committee of the American Standards Association, preliminary steps were taken toward an extensive research program on screw threads. This project was planned, in general terms, during the London Conference as an essential move in bringing about a unification of screw thread standards in the United States, Canada, and the United Kingdom.

MEASURING THE COEFFICIENT OF RESTITUTION AND THE SPIN OF A BALL.

In the *Journal of Research* for January, Lyman J. Briggs, Director of the Bureau, discusses four methods for measuring the coefficient of restitution of a partially elastic ball when struck, and its spin when

* Communicated by the Director.

the ball rebounds from a smooth, inclined plate after striking it at a known angle.

The experiments on which this paper (RP 1624) is based, were made by Dr. Briggs several years ago when he was chief of the Mechanics and Sound Division. Golf balls and baseballs of prewar quality were used in the work, and four methods of determining the coefficient were tried.

The first method was originally developed by Prof. H. A. Thomas of the Carnegie Institute of Technology and employs two ballistic pendulums. The ball is placed on a rubber tee a short distance in front of the muzzle of a horizontal air gun that fires a flat-nosed wooden projectile. When the ball is struck it passes through the first pendulum and is caught in the second, whereas the projectile, being of larger diameter than the ball, is caught in the first pendulum. The deflections of the two pendulums, from which the velocities of the ball and projectile can be calculated, are shown by recording pointers (*Technical News Bulletin* No. 252, April 1938).

A method based on spark photography was next used. The procedure is similar to that adopted in photographing projectiles in flight, and yields interesting shadow pictures from which the ratio of the speed of the ball to that of the projectile can be determined.

As a third method, the vertical rebound of a ball when dropped from a known height onto a massive horizontal plate is measured, correction being made for air resistance.

The fourth and last method is based on the measurement of the angle of reflection of a ball rebounding from a smooth, inclined plate, the angle of incidence being known. In using this method, a correction for spin must be applied because the plate, of necessity, is not ideally smooth. The various ways in which the spin velocity can be measured are outlined, and an approximate method is given for computing the spin when the coefficient of restitution is known.

The variation of the coefficient of restitution of golf balls with impact speed and with temperature was determined experimentally, and a method for finding how long the ball remains in contact with the club is described. The coefficient of restitution (which is approximately 0 for a plastic material like putty and nearly 1 for a highly elastic material such as steel) is, for a golf ball when hit hard, roughly 0.7 and for a baseball, 0.45.

FREEZING POINTS OF NICKEL AND COBALT.

Freezing points of metals serve as accurate reference points in the measurement of high temperatures. Very accurate measurements are required to establish these points, which now include silver, gold, platinum, rhodium and iridium. The freezing points of nickel and cobalt have just been added to the list of such reference points. Calcu-

lated on the International Temperature Scale these freezing points are: Nickel, 1455° C.; and cobalt, 1495° C.

EVALUATION OF SURFACE FINISH ON METAL.

During recent years great progress has been made in the art of mechanically finishing metal surfaces, as regards both quality and control of the finish. However, no method of specifying a finish particularly has, heretofore, been developed sufficiently to be universally acceptable to industry. An important element in such specifications is the evaluation of the depth of surface markings or serrations. Although several devices now used for making this measurement have proved useful, they nevertheless have certain limitations. A method of qualitatively evaluating a surface finish, developed by Harry K. Herschman of the Bureau's Metallurgy Division, appears promising in connection with the preparation of specifications and the establishment of standards.

The method which is described in the January *Journal of Research* (RP 1625), is based on the use of a nearly transparent plastic replica of the surface. The accuracy of reproduction of minute surface characteristics in such a film is attested by the fact that similar replicas are used in the study of metal microstructures at high magnifications with the electron microscope. In the present case, the film is formed by applying a suitable solvent to the metal surface, following which a strip of preformed plastic film is pressed on. The solvent softens the side of the film adjacent to the surface being examined and thus permits it to flow and conform under pressure to the surface irregularities. The replica thus formed dries in about one minute and then is stripped readily from the surface.

In evaluating the finish, a narrow beam of light is passed transversely through the moving replica, and thence onto a photoelectric cell. Variations in the geometric characteristics of the replica that correspond to the serrations in the metal surface control the intensity of the light transmitted through the film and reaching the photocell at any instant. The variation in light intensities produces a fluctuating voltage in the photo-cell circuit, which can be measured with an electronic voltmeter. The voltage readings increase with increased roughness of surface finish. The voltage readings can be translated into "roughness" evaluations by calibrating the voltmeter in terms of profile measurements of the surfaces, determined by microscopical means.

WEARING QUALITY OF SOLE LEATHER.

Recent service tests of 20 commercial tannages of vegetable sole leather have shown that the differences in their wearing qualities are

quite small. The difference between the best and the worst of the tannages was less than 16 per cent., and 15 of the tannages were within 5 per cent. of the average. The tests also showed that additional compression of the soles, similar to that produced by heavy rolling, resulted in an improvement of 5 per cent. in the wear. The soles were tested on 500 pairs of shoes worn by a regiment of Officer Candidates at Camp Lee, Virginia, and by workers in war industries, all tests being under the supervision of Robert B. Hobbs and Ruth A. Kronstadt of the Bureau's leather section.

The tests also indicated that there was no significant difference in the wear of leather tanned from domestic and from frigorifico hides; that water-soluble material and grease are lost from soles in service, with the greatest loss being shown by water-soluble ash; that the so-called "rubber" and "leather" abrasive machines are of little use in predicting the relative wearing qualities of tannages; and that the water-soluble content, firmness, and degree of tannage are useful in estimating the wearing quality. The complete report on this work will be published as RP 1626 in the *Journal of Research* for January.

EFFECT OF TYPE OF BAR ON WIDTH OF CRACKS IN REINFORCED CONCRETE.

Cracking of reinforced concrete subjected to tension is generally recognized as an unavoidable evil and frequently, in order to minimize the width of tensile cracks in some structures, designing engineers use reinforcement steel in excess of the amount needed for strength. While this practice may achieve its purpose, it is possible to avoid wide cracks, with more economical use of steel, by securing better bond between concrete and reinforcement steel.

The tests recently completed by D. Watstein and N. A. Seese, Jr., were made to determine the effect of bonding efficiency of various types of deformed bars upon the widths of cracks in symmetrically reinforced specimens under axial tension. The relative bonding efficiencies of the bars were determined with test specimens of a new type by measuring the strain transmitted by the bar to the surrounding concrete. The bonding efficiency of the bars was found to be an index of the width of cracks observed in reinforced concrete specimens subjected to tension.

Eight types of commercial reinforcement bars were tested. It was found that the bar having the highest bond-efficiency developed cracks the width of which was only 0.46 of that observed with the plain bar having the least bonding efficiency, when both bars carried a stress of 40,000 lb/in.^{2}.

CORROSION OF UNDERGROUND PIPE LINES.

Recognition of the facts that no iron or steel pipe which is economically available can be expected to last long in some soils and that

protective coatings usually only delay corrosion, has emphasized the importance of other methods of protecting pipe. The most promising of these is electrical. If electrical connections are so made that current flows to the pipe line, the pipe will be protected from corrosion. This is done in many installations by supplying energy from a power plant. Considerable use is also made of zinc anodes electrically connected to the pipe lines. In 1941 the Bureau began a series of field tests to determine the conditions under which this method of protection may be effective. (*Technical News Bulletin* 296, December 1941.) Experimental combinations of zinc and steel were buried at eight test sites, so arranged as to give different ratios of area of zinc to that of the steel. During the last month some of the specimens from a site near Shreveport, were returned to the Bureau. These show that a sample of steel not connected to the zinc lost from 40 to 50 times as much metal as similar samples connected to zinc anodes. These observations are, of course, preliminary and further measurements will be necessary in order to determine the best methods of using the zinc. Moreover, it may be found possible to replace the zinc by aluminum or magnesium, thus providing a use for these metals of which large quantities are likely to be available. Arrangements are being made to bury test sets of these metals during the coming spring.

Ice Overcoats Save Cranberry Vines.—Between the microscope and the telescope there are thousands of ways that science has of finding new facts. There are ways that are highly refined, perhaps limited to a drop of water, or those of great scale that may require a flood. The U. S. Department of Agriculture used the latter method in solving the oxygen starvation or smothering of cranberry vines.

Working with horticulturists of the Wisconsin Agricultural Experiment Station, the Department found that an important factor in keeping down yields was lack of sufficient oxygen in winter when the bogs were flooded to prevent injury by cold. The solution of the problem was found to be to use the water to put over the field an ice cover enclosing air or to put on a cover that would be so cold as to reduce plant activity and keep the demand for oxygen low.

The results showed that when the bogs were flooded in the fall and then drained after a thin shell of ice had formed, the rate of survival was much better. When the bogs were flooded a little at a time so as to build up a solid cover of ice, the vines also lived better through the winter.

Now practically every cranberry grower in the State uses one or the other method, and the yield per acre in Wisconsin has gone up more than 50 per cent., in large part because of this improved protection. In fact, the five-year average production for the year ending 1943 was more than 105,000 barrels, while the average yield for the five years ending 1938 was about 75,000 barrels and for the five years ending 1931 about 45,000 barrels. An improved practice that insures profitable crops leads to the use of improved practices in other respects, and this case is an example of this principle.

R. H. O.

THE FRANKLIN INSTITUTE.

ANNUAL MEETING, JANUARY 17, 1945.

The Annual Meeting of The Franklin Institute was called to order by Mr. Charles S. Redding, President, immediately after the playing of the National Anthem, when the audience stood at attention.

The President extended greetings to members of the British Newcomen Society in North America attending the meeting, after their annual Benjamin Franklin Birthday Dinner, held at The Franklin Institute. He then announced that the January meeting is the Annual Meeting of the Institute and requested the members to approve the minutes of the November meeting which appeared in full in the December JOURNAL. As there were no corrections the minutes stood as printed.

Dr. Henry Butler Allen, the Secretary, was then called upon and made the following report regarding additions to membership in the past month.

Associate Life	1	
Active	44	
Associate	25	
Student	41	
Library Sustaining	2	(Representing 8 people)
Total	113	
Total Membership as of December 31, 1944	5,579	

The Secretary then stated that in accordance with the By-Laws, Tellers had been duly appointed to count the election returns. He then read the following report submitted by the Tellers:

President (to serve one year)	Charles S. Redding
Vice-Presidents (to serve one year)	Walton Forstall
	W. Chattin Wetherill
	Samuel S. Fels.
	Richard W. Lloyd
	Richard T. Nalle
Treasurer (to serve one year)	Morton M. Price
Managers (to serve three years)	Edward G. Budd
	Hiram S. Lukens
	Orus J. Matthews
	Morton Gibbons-Neff
	George Wharton Pepper
	George P. Rea
	James S. Rogers
	Clarence Tolan, Jr.
(to serve two years)	Ralph Kelly
(to serve one year)	Rupen Eksergian

Respectfully submitted,

GEORGE S. CRAMPTON,
JAMES D. LEE, JR.,
J. LOGAN FITTS,
Tellers.

The Secretary declared the gentlemen named duly elected to the respective offices for the times indicated.

The Secretary and President both expressed their gratitude to the Tellers for their very real service to the Institute.

Mr. Redding, in the name of himself and fellow officers and Board of Managers, expressed appreciation to the membership for their vote of approval in returning them to office.

He then read the annual report of the President, which had previously been submitted to the Board of Managers, and stated that the report was given at the request of that body to the membership of The Franklin Institute at this Annual Meeting.

(The report in full follows these Minutes.)

Introduction of the speaker of the evening was then made by the President. Sir Louis Beale, K.C.M.G., formerly Co-ordinator of Empire and Allied Requirements, British Supply Council in North America, gave an outstanding talk on Benjamin Franklin entitled "An International Patriot." Sir Louis not only pointed out Franklin's contributions, but from his own fund of information and vast experience was able to compare the problems of Franklin's times with those of today, urging the use of methods which he was sure would be successful in meeting them. Sir Louis' highly informative speech will be published in full in the March number of the Journal of The Franklin Institute.

With a rising vote of thanks to the speaker, the President dismissed the meeting.

HENRY BUTLER ALLEN,
Secretary.

V.2
194

January 17, 1945.

REPORT OF THE PRESIDENT TO THE BOARD OF MANAGERS OF THE FRANKLIN INSTITUTE OF PENNSYLVANIA, COVERING THE OPERATIONS OF THE INSTITUTE FOR THE YEAR 1944.

The Annual Meeting of The Franklin Institute is the time appointed in the By-Laws when the Board of Managers, through the President, shall make a report on the year's activities. The following report, prepared by the President, was today approved by the Board of Managers, and the President was instructed to present it to the membership of the Institute this evening as the report of that body.

This is a brief summary of the activities of The Franklin Institute, together with a statement of its financial status, for the year 1944.

The property of the Institute is entered on the books at $5,790,600. Of this amount, real property (building and equipment, not including those exhibits which have been donated) amounts to $4,119,800, and personal property (securities and cash) amounts to $1,670,800. The value of real property here reported is $4,800 higher than that reported for the preceding year, due to the purchase of some equipment items during the year, and increase in inventoried supplies. The value of personal property is $9,800 higher than that reported for the preceding year. Contributing to this is an increase in cash at the end of 1944 of $38,200 over balance at the end of 1943, less principal losses in sales of securities, particularly real estate and mortgages.

Gifts, exhibits, etc., acquired by the Institute during the past year, must also be regarded as property, but are not given a monetary value on our books.

At the end of 1944, The Institute's investments in securities were:

Largely available as to income only	$651,200.00
Available unrestrictedly	911,500.00

The following figures, covering income and expense, represent a close estimate of the financial operation of the Institute for the year. Final figures will not be available until the closing of the books some weeks hence.

Income	
From:	*1944*
Dues	$ 59,500.00
Admissions	45,500.00
Investments	60,000.00
Other sources	660,000.00*
Friends of Franklin	23,000.00
Total	$848,000.00

Expenses	
	1944
General	$188,300.00
Museum Operation	102,400.00
Library	15,500.00
Publications	16,300.00
Meetings	1,900.00
National Franklin Committee	12,200.00
Other	472,100.00†
Total	$808,700.00
Gain for the year	$ 39,300.00

* $585,000 of this item represents work done for and space provided to Government Departments in connection with war work, after estimated provision for a redetermination downward by the Government auditors of the overhead expense charged on government contracts.

† All but $5,800 of this item covers direct outlay in connection with Government work.

As to this year's estimated gain of $39,300.00, I call your attention to the fact, as I did with respect to the gain from the year 1943, that the gain is entirely due to the large amount of Government work done at the Institute during the year. This favorable financial situation will not continue after our war work ceases. Then, as before the war, our problem will be to find ways and means of balancing the budget. Although the war work of the Institute prevents at this time active prosecution of plans to that end, they are in the making and will be actively worked upon just as soon as possible.

Despite difficulties of travel and the fact that our Museum is not being maintained as it was during normal years, attendance, both paid and free, at the Museum and Planetarium has shown a notable increase over the previous year as shown in the following table:

	Museum		*Planetarium*		*Total*	
	1944	*1943*	*1944*	*1943*	*1944*	*1943*
Paid	123,964	106,383	74,063	53,647	198,027	160,030
Free	45,631	33,037	35,728	22,998	81,359	56,035
Total	169,595	139,420	109,791	76,645	279,386	216,065

While the total membership is somewhat below that of last year, now totalling 5,579 in all classes, our Membership Committee and the staff working under the direction of that Committee have our thanks and commendation for the results of the efforts put forth.

The Board of Managers and officers are deeply grateful to those constituting the Friends of Franklin for their continuing generosity. At the present time their contributions are used to replace inroads made on our capital in the past lean years, and we earnestly bespeak the co-operation of this fine group during the trying reconversion period ahead. Without their very substantial assistance our task will prove difficult indeed.

The war has again been the dominant factor in our plans for the Museum and Planetarium. We have tried to strike a balance between our war efforts and our so-called "normal" activities, the preference of course going to the war when any choice had to be made. During the year additional space has been turned over for our war contracts, which have increased in amount and variety. Our personnel has increased from 228 during 1943 to 294 in 1944. It is interesting to note that as of December 31, 1942, there were 159 persons on the Institute payroll. This is an increase to date of just about 85 per cent. and is entirely due to our war work.

The maintenance of our exhibits has fallen below our standards, due to shortage of materials and skilled workers. This problem is particularly serious with us, since so many of our exhibits are "visitor-operated" and require careful maintenance. Despite everything, it is very gratifying that there has been very little public criticism, either of the reduced museum space available, or of the exhibits not being in good condition. In fact, as noted above, attendance for both Museum and Planetarium has increased.

The year was marked by constantly increasing co-operation between the Department of Museum Education of the Institute and the public, parochial and private schools of the Philadelphia area. The Board of Education assigned a teacher with museum experience to The Franklin Institute, to aid in handling school groups. The work has been eminently successful.

The Education Department has conducted study visits for teachers, and faculty meetings of various schools have been combined with tours of the building. A number of exhibits, which otherwise would be kept in storage, have been lent to schools, allowing demonstrations and at the same time publicizing the Institute.

The war has quickened interest in astronomy and meteorology, so that special courses in these subjects were offered during the year.

Through the efforts of our Public Relations Department, in a year marked by drastic curtailment of newsprint and radio, the Institute has received the benefit of increased space and announcements. This Department inaugurated a plan for educational school radio broadcasts which is carried out by our Educational Department, in co-operation with the

Philadelphia Board of Education and WFIL. The program, for younger students, known as "Science is Fun" and given at 2:15 p.m. on Mondays, won instant approval from sponsors and student audiences. A more recent program, for high school students and adults, given at 1:45 p.m. on Tuesdays, and sponsored by WIP, is rapidly gaining an interested following.

The theme, "Science is Fun," is carried out in a small booklet outlining the Museum and Planetarium. Thousands of copies have been distributed. It is also used with good effect on our sign boards outside the Institute, and on smaller placards displayed to catch the public eye.

Photographic exhibits by industry have continued through the year as a Museum feature. Here our own public relations group has been instrumental in getting publicity for both the exhibitor and the Institute.

A valuable aid in helping the Institute to extend the influence of Benjamin Franklin was the publication of a set of lectures given at the Institute a few years ago entitled "Meet Dr. Franklin." Put in book form and promoted by a special campaign, over four hundred copies were sold in one month.

We feel that all departments of the Institute have benefited by the informed direction of our Public Relations Department. The concrete evidence is in the increase in paid attendance and the sale of our publications.

The Franklin Institute since 1824 has always found an ally in industry. We are pleased to report that through our Industrial Co-operation Plan, the Institute has received $20,000 during 1944, plus good-will and real aid in creating and improving exhibits in the museum. The Davison Chemical Corporation, the SKF Industries, the Atlantic Refining Company, and the E. I. duPont deNemours Company are among the new contributors to this important work at the Institute. Due to the war, we have been retarded in our efforts to improve many of our present industrial exhibits, or to acquire new ones. We are confident, however, that the companies already associated with us will not lose interest, and that new ones will gradually join with us. The importance of this connection between the Institute and industry cannot be overestimated.

This relationship is fostered also through the Library of the Institute. Members of the Institute, engaged in research work for industry, find the Library here a storehouse of information. During the past year there were 7,380 visits to the Library by members and 1,020 by non-members. There were 6,670 calls by telephone for information. Where it was necessary to have the information for outside consultation from publications not in circulation, photostat copies were procured—9,818 being ordered during the year. Due to the difficulty of getting properly trained assistants, the Library is understaffed. The fine service rendered therefore takes on added significance.

In 1944, 375 new books were purchased and 543 received as gifts, together with 450 maps. 1,384 pamphlets were added to our large collection. Total contents of the Library as of December 31, 1944, were:

128,752 volumes
44,966 pamphlets
3,899 maps

The award of medals has brought lasting renown to The Franklin Institute. The members of the Committee on Science and the Arts are therefore to be especially commended for the efforts made to maintain the high standards expected of that body. During the past year they have attended nine regular meetings and forty-two sub-committee meetings—an excellent record for men whose own activities demand so much of them during war time. In 1944, as a result of their deliberations, twelve medals and one Certificate of Merit were awarded. Two new medals were awarded for the first time: The Newcomen Medal to Rear Admiral H. G. Bowen, and the Clamer Medal to W. E. L. Mathesius. The history of both medals was given in my report of last year. It should be mentioned that the award of a Franklin Medal to the Russian scientist, Peter Kapitza, brought international publicity to the Institute.

As usual, twelve numbers of the Journal were issued during the year. While, due to the war, there has been at times a scarcity of material, the tendency is gradually towards the receipt of more articles for publication and it is anticipated that this will grow. Members will notice that advertising, under the able guidance of the Membership Department, has greatly increased.

The status of our two research foundations, the Bartol and Biochemical, remained unchanged in 1944. As reported last year, all their efforts are devoted to the war and cannot be reported upon at this time.

The National Franklin Committee continues to extol the homely virtues of Benjamin Franklin, with resultant good, we hope, to the youth of America. Hundreds of mimeographs giving accounts of varied activities of this great American have been distributed throughout the year; radio talks and speeches have been given, and nationwide publicity for The Franklin Institute and the National Memorial to Benjamin Franklin was obtained during last January, in commemorating Franklin's Birthday.

The Committee suffered a severe loss last summer in the death of its Chairman, Mr. W. M. Vermilye. He was an inspiring leader and just before his death had arranged to devote his time almost exclusively to the work of the Committee. Due to his activities, an office was maintained in New York. This fall the Board of Managers decided that the office should be given up. The work will be continued here at the Institute.

The Hostess Committee has continued to function and has been an invaluable ally to the Officers, the Board of Managers, and the staff, particularly in the part it has taken in providing the enjoyable social features in connection with many of our gatherings. That Committee was responsible, both financially and socially, for the reception preceding the Annual Medal Day Dinner, for a tea in honor of Lieutenant Guy Marriner following his recital in May, for a reception to approximately three hundred members of a Special Library Conference held in Philadelphia attended by representatives from all over the country, and for a reception and tea following the special meeting of the Institute in September when the Army Ordnance Award was received. During the year, Mrs. John White Geary was re-elected Chairman of the Hostess Committee, a position she has held with enthusiasm for several years. We are all deeply indebted to Mrs. Geary and her co-workers.

V.2
194

Members of The Franklin Institute have proved by their attendance that they find the technical lectures both interesting and enlightening. Fifteen such meetings were held during the year, some in conjunction with other technical societies. The average attendance was 208. These meetings, preceded by a subscription dinner, are very pleasant occasions. During the past season a new feature, "Meet the Lecturer," has been added, whereby each individual attending the dinner is personally introduced to the speaker of the evening. It has resulted in many gratifying comments.

In addition to our own meetings, our lecture room and other places throughout the building are in constant demand for meetings by kindred organizations. In all 386 meetings took place during 1944.

The special meeting of The Franklin Institute held in September should be emphasized, for it was held to receive from the Ordnance Department of the United States Army the Ordnance Distinguished Service Award, bestowed for the outstanding contributions The Franklin Institute has made to Ordnance progress in the war. The Award was a diploma bearing the traditional seal of the Ordnance Department and was given in recognition of scientific and engineering achievement.

The war work of the Institute cannot be made public, but its members can take a just pride in this honor, and in the fact that Major General L. H. Campbell, Jr., Chief of Ordnance, came personally from Washington to present it.

Another set of lectures at The Franklin Institute which deserves special mention are the Christmas Week Lectures for Young People on the James Mapes Dodge Foundation. Annually, for three days between Christmas and New Year's, the young people of the City are given an opportunity to hear discussed, in language largely devoid of technical terms, some

important scientific topic. The lectures are always accompanied by interesting demonstrations, and the audience is encouraged to ask questions and handle the exhibits. In December, the timely topic, "Flying by Instrument," was discussed. Mrs. Dodge, who endowed the lectures in memory of her husband, is always one of the most interested spectators.

It is with a sense of deep loss and sorrow that I record in this report the death on June 21, 1944, of Nathan Hayward, beloved former President of the Institute. He became a member of the Board in 1917 and served as President from 1929 to 1937. After retiring from the presidency he continued as a member of the Board until the time of his death. He gave unstintingly of his time, counsel and means to this institution which he served so long and which he loved so well.

In connection with the National Franklin Committee I have noted the death of another member of the Board, William M. Vermilye. His death occurred on August 30, 1944. He had been a member of the Board only a year but his interest in the Institute extended over a much longer period of time. It will be remembered that in 1939 he established the Vermilye Medal, to be awarded biennially by The Franklin Institute in recognition of outstanding contribution in the field of industrial management. He had won the affection of his fellow Board members and will be sadly missed.

The By-Laws provide that all vacancies shall be filled by the Board of Managers until the next annual meeting of the Institute. Accordingly, the following gentlemen have honored us by accepting membership on the Board:

George P. Rea, Chairman, Southeastern Pennsylvania Chapter, American Red Cross;
Ralph Kelly, President, The Baldwin Locomotive Works;
Morton Gibbons-Neff, Insurance Broker and former President of The Poor Richard Club.

May I end this report with a personal word. I have served The Franklin Institute for three years as its President. Unless something unusual in the annals of the Institute should occur, or perhaps I should say, has occurred, I shall tonight start my fourth year. It has been to me a source of very real pleasure and inspiration to have occupied that position. To the other Officers and to the Members of the Board of Managers, I again express my deep appreciation for their friendly and helpful co-operation in endeavoring to perpetuate the ideals and objectives of The Franklin Institute. To the men and women of the staff, my sincere thanks for their earnest and effective services during 1944—a year in which continually increasing activity placed extra loads on all. It is to that group, headed by Dr. Allen, that credit is due for the accomplishments of the year.

CHARLES S. REDDING,
President.

COMMITTEE ON SCIENCE AND THE ARTS.

(Abstract of Proceedings of Stated Meeting held Wednesday, January 10, 1945.)

HALL OF THE COMMITTEE,
PHILADELPHIA, JANUARY 10, 1945.

MR. WILLIAM B. COLEMAN *in the Chair.*

The following reports were presented for final action:

No. 3142: Work of Admiral Stanford C. Hooper.

This report recommended the award of an Elliott Cresson Medal to STANFORD CALDWELL HOOPER, of Washington, D. C., "In consideration of his pioneering leadership and practical utilization of discovery in the field of radio for the U. S. Navy."

No. 3143: Franklin Medal.

This report recommended the award of a Franklin Medal to HARLOW SHAPLEY, of Cambridge, Massachusetts, "In consideration of his many valuable contributions to the science of astronomy, and especially of his work in the measurement of the vast distances necessary for the determination of the nature and extent of our galaxy, as well as those of other galaxies external to ours."

No. 3144: Levy Medal.

This report recommended the award of a Louis Edward Levy Medal to RUPEN EKSERGIAN, of Upper Providence, Pennsylvania, "For his paper 'On the Reaction of Fluids and Fluid Jets,' which appeared in the May 1944 issue of the Journal of The Franklin Institute."

JOHN FRAZER,
Secretary to Committee.

LIBRARY NOTES.

The Committee on Library desires to add to the collections any technical works that members would wish to contribute. Contributions will be gratefully acknowledged and placed in the library. Duplicates received will be transferred to other libraries as gifts of the donor.

Photostat Service. Photostat prints of any material in the collections can be supplied on request. Orders received in the morning are filled the same day. The average cost for a print 9 × 14 inches is thirty-five cents.

The library and reading room are open on Mondays, Tuesdays, Fridays and Saturdays from nine o'clock A.M. until five o'clock P.M., Wednesdays and Thursdays from two until ten o'clock P.M.

RECENT ADDITIONS.

AERONAUTICS.

GILLMER, THOMAS C., AND H. ERICH NIETSCH. Clouds, Weather and Flight. 1944.

U. S. Hydrographic Office. Aircraft Navigation Manual. U. S. Navy. First Edition, Revised. 1941.

ARCHITECTURE AND BUILDING.

HOOL, GEORGE A., AND W. S. KINNE, Editors. Reinforced Concrete and Masonry Structures. Second Edition. 1944.

AUTOMOTIVE ENGINEERING.

JENNINGS, BURGESS H., AND EDWARD F. OBERT. Internal Combustion Engines. First Edition. 1944.

BIOGRAPHY.

PEPPER, GEORGE WHARTON. Philadelphia Lawyer. 1944.

CHEMISTRY.

HERZFELD, K. M., AND OTHERS, Editors. English-Russian Dictionary on Chemistry and Chemical Technology. 1944.
KIRSCHENBAUER, H. G. Fats and Oils. 1944.

ELECTRIC ENGINEERING.

CURTIS, FRANK W. High-Frequency Induction Heating. First Edition. 1944.
KINKEAD, ROBERT E. Practical Design for Arc Welding. Volume I. 1943–1944.

ENCYCLOPEDIAS.

Britannica Book of the Year. 1944.

MANUFACTURES.

HARRIS, P. BUFORD. Modern Watch and Clock Repairing. 1944.

MATHEMATICS.

FISHER, RONALD A., AND FRANK YATES. Statistical Tables for Biological, Agricultural and Medical Research. Second Edition. 1943.
KRAITCHIK, MAURICE. Alignment Charts. 1944.
NEVILLE, ERIC HAROLD. Jacobian Elliptic Functions. 1944.
PETERS, CHARLES C., AND WALTER R. VANVOORHIS. Statistical Procedures and their Mathematical Bases. First Edition. 1940.

MECHANICAL ENGINEERING.

FELLER, EUGENE W. F. Air Compressors. First Edition. 1944.
HOUGHTON, P. S. Press Tool Practice. Two Volumes. 1943–1944.
KARASH, J. I. Analysis of Drill-Jig Design. First Edition. 1944.
MADISON, RICHARD D., Editor. Fan Engineering. Fourth Edition. 1938.

MINING AND METALLURGY.

American Institute of Mining and Metallurgical Engineers. Transactions. Coal Division. 1944.
MERLUB-SOBEL, M. Metals and Alloys Dictionary. 1944.
ROLFE, R. T. Steels for the User. Second Edition. 1944.

NAVAL ARCHITECTURE AND NAVIGATION.

GARYANTES, H. F. Handbook for Shipwrights. First Edition. 1944.
LAING, ALEXANDER. Clipper Ship Men. 1944.
MEFFERD, GERRY. The Cruising Manual. 1941.

PHOTOGRAPHY.

U. S. Camera 1945: The U. S. A. at War. 1944.

PHYSICS.

MYKLESTAD, N. O. Vibration Analysis. First Edition. 1944.

SUGAR.

Gilmore's Cuba Sugar Manual. 1944.

ARMY AND NAVY NOTES.

Gyro Stabilizes Tank Gun in Action.—C. R. HANNAH, Manager of the Electro-Mechanical Department, and L. B. LYNN, Research Engineer of the Westinghouse Research Laboratories, recently described a tiny gyrostabilizer which enables gunners in American tanks to fire accurately while racing across rough battlefields, in spite of the pitching and rolling of the tank. The stabilizer keeps the gun barrel at a fixed elevation and the target within focus of the gunner's telescope sight, thus greatly increasing the accuracy and efficiency of the moving tank gun. In effect, the electro-hydraulic stabilizing system floats the tank gun about its trunnions so that the gun barrel remains at a fixed elevation regardless of the lurching of the tank. At tank speeds of approximately 15 miles per hour over typically rough cross-country terrain, the device makes possible better than 70 per cent. hits over a target range of 1,200 down to 300 yards. Without the stabilizer, even experienced gunners were unable to score 1 per cent. hits under similar conditions. This ability of American tanks to shoot accurately on the run gives a tremendous advantage over enemy tanks which must ordinarily stop to fire.

The same principles that enable American tanks to fire on the run with much deadly effect promise to provide "floating" rides in high-speed trains and other vehicles. Calculations show, for example, that only about three horsepower are needed to stabilize the vertical movement of a railroad coach. Stabilizer power and size vary as the mass and the square of the fluctuations. Thus, an automobile and a railroad car would require units of about the same size since the excessive vertical vibration of an automobile compensates for its lightness. The railway and automotive fields are merely typical of possible applications of the general principles of the stabilizer since such principles are applicable wherever stability is required in a member of a body in motion.

The four basic components of the gyro-stabilizer system used for tank guns are (1) the gyro motor, (2) the silverstat regulator, (3) the oil pump system including the electro-magnetically controlled valves, and (4) the piston and cylinder assembly. The gyro control tends to maintain the tank gun fixed in its aimed position. Tank fluctuations tending to alter this position precess the gyro which, through the silverstat, varies the current to the electro-magnet valves. The valves are affected in such a fashion that the oil pressure above and below the piston increases and decreases in accordance with the signal current. Since the piston is fixed to the gun, its movement to the low pressure side maintains the gun in the aimed position.

R. H. O.

V.23
1945

THE FRANKLIN INSTITUTE

BY-LAWS

ARTICLE I.

Stock.

Section 1. The Real and Personal Estates of the Institute as held upon the First day of January, One Thousand Eight Hundred and Eighty-one, shall be valued at One Hundred Thousand Dollars, and shall be represented by Ten Thousand Shares of Stock of the par value of Ten Dollars each. Said shares shall be divided into two classes, *viz.*:

First Class. Shares not registered for use: on which no annual payment shall be charged or collected, and the holders thereof shall not have the privileges of members of the Institute, but may, if of legal age, vote at any annual election for officers and managers upon the payment of One Dollar upon each share of stock on which they may desire to vote; provided, however, such shares have been held by the same person at least three months before such election.

Shares of the First Class may be converted into shares of the Second Class at the pleasure of the owners, provided the transfer be approved by the Board of Managers; but, when once so converted, they shall always continue in the Second Class.

Second Class. Shares registered for use: on which Twelve Dollars per annum shall be due and payable from resident members in advance on the first day of October in each year, except as hereinafter provided.

Non-resident holders of Second Class stock shall pay an annual fee of Five Dollars.

Section 2. The holders of Second Class stock shall be entitled to the use of the library, lectures and reading-room; and, if of legal age, to all other privileges of membership in the Institute, so long as they make the annual payment in advance; and shall, on the payment of One Dollar therefore, be entitled to a Certificate of Membership.

Section 3. If the annual dues for successive years remain unpaid at the expiration of two and a half years on any share of stock of the Second Class, such shares shall then become forfeited to the Institute; but such forfeiture may be remitted by a unanimous vote of the Board of Managers.

Section 4. Stock of the Second Class may be held in trust for persons not of legal age, and shall be liable to the payment of only one-half the annual fees due upon stock of Second Class held by persons of legal age; provided, that when such minors arrive at legal age, new certificates, subject to the full annual contribution, shall issue on payment of the customary fee.

Section 5. Certificates for the First Class stock may be issued for any number of shares in a single certificate; but every certificate for the Second Class shall be for one share only.

Section 6. No share of stock in the Second Class shall be transferred until all arrearages and fines are paid, and all books and tickets returned, and the transfer approved by the Board of Managers.

Section 7. All certificates of stock shall be signed by the President and Secretary; shall be issued by the Controller, and shall be transferable only on the books of the Institute by the owner, or his legal representative, on the surrender of the old certificate, and of a fee of twenty-five cents for each certificate.

Section 8. All subscriptions to stock shall be approved by the Board of Managers before the certificate can be issued.

ARTICLE II.

Members.

Section 1. All persons interested in the purposes and activities of the Institute and willing to further them may become members when elected by the Board of Managers, or in a manner prescribed by the Board, except as qualified by Section 6 of this Article.

Membership shall consist of the following classes:

1. Student members
2. Associate members
3. Active members
4. Sustaining members
5. Honorary members

The Board of Managers may establish other classes of members, provided that the privileges enjoyed and dues paid by such other classes are not inconsistent with the privileges and dues of the classes of members specifically provided for by these By-Laws.

Section 2. Student members shall be under twenty-five years of age and shall pay annual dues of $2.00. They shall be entitled to unlimited free admission to the Museum and the Planetarium. Student members who are fourteen or more years of age may, if endorsed by a teacher or an Active member, have the use of the library upon the payment of additional annual dues of $1.00 but shall have no voting privileges or rights to hold office.

Section 3. Associate members shall pay annual dues of $5.00. They shall be entitled to unlimited free admission to the Museum and to the Planetarium, but shall have no voting privileges or rights to hold office. Upon the payment of $5.00 additional annual dues they shall have Family privileges as defined in Section 7 of this ARTICLE.

Section 4. Active members shall be not less than twenty years of age. They shall pay annual dues of $15.00. Active members, residing permanently at a distance of fifty miles or more from Philadelphia, shall pay annual dues of $7.50. Active members shall be entitled to use the library, to receive one copy of the Journal of The Franklin Institute, to vote and to hold office. They shall be entitled to all the privileges of Associate Members and upon the payment of $5.00 additional annual dues shall be entitled to Family privileges.

Section 5. Sustaining members shall be not less than twenty years of age. They shall pay annual dues of not less than $50.00. They shall be entitled to all of the privileges of Active members and shall have Family privileges as defined in Section 7 of this ARTICLE free of additional charge.

Section 6. Honorary members shall be entitled to all of the privileges of sustaining members, except the right to vote and to hold office. They shall be nominated by the Board of Managers and shall be elected by four-fifths of the votes of the members present at any stated meeting of the Institute at which their nomination may be acted upon.

Section 7. Family privileges consist of the right to receive a card for each individual in the family of the member and resident with the member entitling the holder to unlimited free admission to the Museum and the Planetarium.

Section 8. Members belonging to classes of membership existing prior to the amendment of this ARTICLE shall be reclassified in a manner consistent with their former dues and privileges.

ARTICLE III.

PAYMENT OF DUES.

Section 1. The annual fees for membership shall be due and payable on the first day of each month, whichever is nearest to the date of election or as determined by the Board of Managers.

Section 2. Any member whose dues are more than two months in arrears shall have all the privileges of membership suspended until such time as all arrears are paid. Should the dues not be paid when they become six months in arrears the said member shall forfeit his membership.

Section 3. The Board may remit temporarily in whole or in part the dues of any member either by action in a particular case or by establishing regulations governing certain cases.

Section 4. Every person admitted to membership in the Institute shall be considered as liable for the payment of dues until he shall have resigned, been dropped or have been relieved therefrom by the Board of Managers.

Section 5. Resignations of memberships shall be made to the Board of Managers in writing, but need not be accepted until all dues and arrears up to date of resignation shall have been paid.

Section 6. The privileges and title of Associate Member may be obtained for life by paying therefor in one year the sum of $100. From this payment may be deducted one-half of the Student or Associate Membership dues

paid by the member during the preceding ten years, but in no case shall the deduction exceed $50.00.

Section 7. The privileges and title of Active Member shall be enjoyed for life or may be obtained for life by a member who has heretofore or who shall hereafter pay therefor, in one year, the sum of $300, except that a person residing permanently at a distance of twenty-five miles or more from Philadelphia may become an Active Member for life by paying therefor in one year the sum of $100. From this payment may be deducted one-half of the dues paid by the member during the preceding ten years, but in no case shall the deduction exceed one-half of said payment. Associate Members for life may become Active Members for life by paying therefor in one year the sum of $200.

Section 8. Firms, corporations, associations or individuals may nominate and subscribe for the membership dues of groups of members of any class or classes, at the annual dues provided for, subject to the approval of the Board as to any particular nominee. If the dues of these nominees amount to $100 or more in the aggregate, the firm, corporation, association or individual shall be known as an Affiliate of the Institute.

ARTICLE IV.

ELECTION OF OFFICERS.

Section 1. The officers shall be a President, not more than five Vice-Presidents, a Secretary, an Assistant Secretary, a Treasurer, two Assistant Treasurers, a Controller, a Librarian, a Director of the Benjamin Franklin Memorial and The Franklin Institute Museum, a Manager of Operations of the Benjamin Franklin Memorial and The Franklin Institute Museum, a Board of twenty-four (24) Managers and such other officers as the Board of Managers may elect or appoint.

Section 2. At the annual meeting of the Institute the President, the Vice-Presidents, and the Treasurer shall be elected to serve one year, and eight Managers shall be elected each year to serve for three years; provided, that the officers now elected, or who may hereafter be elected, shall continue to serve until their successors be elected.

Section 3. All elections of the Institute shall be by letter ballot and no vote may be cast by proxy.

Section 4. Nominations for President, Vice-Presidents, Treasurer and Managers shall be made in writing at the stated meeting in the month of December. Each nomination paper must be signed by at least two members, who shall certify that the candidate will serve if elected. After the nominations are closed, the President shall appoint three members, who are neither officers nor nominees, to act as tellers of election. The list of nominees shall be posted at the Institute and incorporated (with directions for voting) in a ballot to be sent to each member by the Secretary at least one week before the date of election. Each ballot shall be accompanied by a return envelope addressed "To the Tellers of Election," and provided with a space for the signature of the member voting.

Section 5. On the date of the annual meeting, and at an hour previously designated by their chairman, the tellers shall meet at the Institute, and shall count all legal votes that have been received by mail or placed in the ballot box before eight o'clock P.M.; and when the count is completed they shall report to the annual meeting of the Institute the total number of ballots cast, together with the number of votes received by each candidate. Thereupon the presiding officer shall announce the names of the candidates who received the plurality of votes, and shall declare them elected officers and Managers of the Institute for the ensuing terms.

Section 6. At the organization meeting of the Board of Managers, the Board of Managers shall elect such other officers provided for in Section 1 of ARTICLE IV; shall elect or appoint such other officers as it may determine upon, and shall determine and fix the compensation, if any, to be paid to the officers so elected or appointed by them. The officers who are in office immediately prior to the annual meeting shall continue in office until their successors are elected or appointed by the Board of Managers as herein provided.

Section 7. Vacancies occurring in any office may be filled by the Board of Managers by election or appointment of persons to serve until the next annual election.

ARTICLE V.

BOARD OF MANAGERS.

Section 1. The Board of Managers shall have general charge and control of the Institute and of the Benjamin Franklin Memorial and The Franklin Institute Museum, and shall consist of twenty-four members elected as provided in ARTICLE IV. The President, the Vice-Presidents, the Secretary, the Treasurer, the Chairman of the Committee on Science and the Arts, and the Chairman of the Library Committee shall be ex officio members. A quorum of the Board of Managers shall be nine of the elected and ex officio members. The Board of Managers may adopt such by-laws, rules and regulations for the governance of their affairs as are not inconsistent with the Charter and these By-Laws.

Section 2. They shall present, through the President, at the annual meeting of the Institute, a report of the condition of the affairs of the Institute.

Section 3. They shall hold stated meetings in each month except in July and August.

Section 4. Special meetings may be called by the President at his discretion and shall be called by him on written request of the Executive Committee or of any seven members of the Board. In case of his absence or refusal to act, such special meeting shall be called by the Secretary.

Section 5. Members who have not attended five regular meetings in the twelve months prior to the stated meeting of the Institute in December, shall be reported thereat as having resigned, unless it be unanimously voted by the Board at that meeting that such member has been absent for sufficient reason.

Section 6. All vacancies on the Board of Managers shall be filled by the Board until the next annual meeting of the Institute.

Section 7. The Board of Managers may elect an Executive Committee consisting of five of its Members with such authority to act on behalf of the Board as the Board may delegate.

ARTICLE VI.

DUTIES OF OFFICERS.

Section 1. The President shall be the executive head of the Institute and, under the supervision of the Board of Managers, shall have general charge of the affairs of the Institute. He shall preside at all meetings of the Institute and of the Board of Managers and shall be ex officio a member of all Committees.

Section 2. The Vice-Presidents shall exercise the duties of the President in his absence in the order of their seniority in office.

Section 3. The Secretary shall have general administrative supervision over all of the affairs of the Institute other than those matters specifically delegated by these By-Laws to the Executive Committee, Finance Committee, and Treasurer. He shall keep the minutes of all meetings of the Institute and of the Board of Managers, and shall perform all the duties usually pertaining to the office of Secretary. He shall prepare the annual budget, submit it to the Finance Committee for first approval, and to the Board of Managers for final approval. He shall be an ex officio member of all Committees. He shall report to the President. In the absence or disability of the Secretary, the Assistant Secretary shall perform his duties.

Section 4. The Director of the Benjamin Franklin Memorial and The Franklin Institute Museum shall have general administrative supervision over the Memorial and Museum, of the exhibits therein displayed, and of the activities centering in the Museum. He shall annually appoint the members of the scientific staff of the Museum, subject to the approval of the Secretary and of the Board of Managers. He may be appointed by the Board of Managers an ex officio member of any Committee. He shall report to the Secretary.

Section 5. The Treasurer shall have custody of all moneys received from the Committee on Finance, together with all moneys received by the Institute from dues, admissions and other incidental collections. He shall deposit in the name of the Institute, in such bank or banks as the Board of Managers may direct, all moneys in his custody. He shall disburse such moneys only upon vouchers certified by the Controller or, in the absence or disability of the Controller, by the Auditor or the Secretary. He shall keep accurate accounts of the income and disbursements of the Institute, shall report current receipts and

V.2
194

payments at each stated meeting of the Board of Managers, and shall make a detailed statement of the financial condition of the Institute at its annual meeting. He shall give bond to an amount, and with such surety, as the Board of Managers shall determine. He shall report to the President. In the absence or disability of the Treasurer, the Assistant Treasurers shall, in the order of their seniority in office, perform his duties.

Section 6. The Controller shall keep the detailed accounts of the Institute, shall collect all moneys due the Institute and shall deposit them in the Treasurer's account. He shall approve all expenditures for payment. He shall act as the business agent of all publications of the Institute, except as the Board of Managers may specifically otherwise from time to time provide. He shall perform such other duties as are assigned to him by the Secretary. He shall report to the Secretary.

Section 7. The Librarian shall have immediate charge of the library and reading-room of the Institute. He shall report to the Secretary.

Section 8. The Manager of Operations of the Benjamin Franklin Memorial and The Franklin Institute Museum shall have immediate charge of the Benjamin Franklin Memorial and The Franklin Institute Museum. He shall have charge of the maintenance and care of all real estate properties of the Institute, and of its shops. He shall report to the Director of the Benjamin Franklin Memorial and The Franklin Institute Museum.

ARTICLE VII.

BOARD OF COUNCILLORS.

The Board of Councillors shall consist of not more than fifty members and shall embrace, as ex officio members, the Governor of Pennsylvania, the Chief Justice of the Supreme Court of Pennsylvania, the Mayor of the City of Philadelphia, the President of the City Council of Philadelphia, the President of the Board of Public Education and the Superintendent of Schools of the City of Philadelphia, the Provost and the President of the University of Pennsylvania, the President of Commissioners of Fairmount Park, the President of the American Philosophical Society, the President of the Poor Richard Club, and the President and Secretary of The Franklin Institute, which two latter shall respectively be Chairman and Secretary of the Board of Councillors. Additional members shall be nominated by the President or Secretary of the Institute and elected by the Board of Managers, at such intervals as the Board of Managers may see fit. The Board of Councillors shall meet at the call of its Chairman or of the Board of Managers for the consideration of any matter that pertains to the welfare of the Institute. The Secretary shall from time to time send to the members of the Board of Councillors a report of the activities and accomplishments of the Institute.

ARTICLE VIII.

COMMITTEES OF THE INSTITUTE.

Section 1. There shall be the following Standing Committees of the Institute:

1. Bartol Research Foundation Committee.
2. Biochemical Research Foundation Committee.
3. Committee on Science and the Arts.
4. Endowment Committee.
5. Finance Committee.
6. Library Committee.
7. Meetings Committee.
8. Membership Committee.
9. Memorial and Museum Committee.
10. Publications Committee.

Section 2. Each standing committee of the Institute shall consist of at least ten members, not more than five of whom shall be members of the Board of Managers, except that the Committee on Science and the Arts shall consist of sixty-six members, without limitation as to the number who may be members of the Board of Managers, and except that the Bartol Research Foundation Committee shall consist of twelve members as provided for in Section 7 of this ARTICLE.

Section 3. The members of each committee shall serve one year, except that members of the Committee on Science and the Arts shall serve three years.

Section 4. The members of each committee, other than ex officio members specifically provided for by these By-Laws, shall be appointed by the President and approved by

the Board of Managers at the organization meeting of the Board following the annual meeting, except that each year but twenty-two members of the Committee on Science and the Arts shall be so appointed and approved.

Section 5. The Chairman of each committee shall be designated by the President, except that the Library Committee and the Committee on Science and the Arts shall select their chairmen. A chairman who is not an elected or ex officio member of the Board of Managers shall have the privilege of the floor at meetings of the Board but shall not have the right to vote.

Section 6. Each committee shall report monthly through its Chairman or through the Secretary, as it may elect, to the Board of Managers.

Section 7. The Bartol Research Foundation Committee shall consist of twelve members, including the President and the Secretary of the Institute and the Director of the Bartol Research Foundation as ex officio members and nine members of the Institute of whom not more than four shall be members of the Board of Managers. The Committee shall, after consultation with the Director of the Bartol Research Foundation and subject to the approval of the Board of Managers, collaborate with the Secretary in carrying out the purposes and determining the policies of the Bartol Research Foundation. It shall appoint the Director and the Staff of the Laboratories, subject to the approval of the Board of Managers. The Director of the Bartol Research Foundation, to whom all other employees of the Foundation shall report, shall have charge of the scientific activities of the Foundation and shall report on all matters to the Committee or to the Secretary, as the Committee may elect.

Section 8. The Biochemical Research Foundation Committee shall report to the Board of Managers from time to time on the condition of the affairs and operation of said Foundation and shall be available to the Director of the Biochemical Research Foundation and its Advisory Council for collaboration and advice.

Section 9. The Committee on Science and the Arts shall investigate current discoveries, inventions and other achievements in the sciences and their application in the mechanical and industrial arts with a view of affording such recognitions as lie within the power of the Institute to bestow. The Committee shall exercise independent judgment therein. In all matters of a general or administrative nature the Committee shall collaborate with the Secretary.

Section 10. The Endowment Committee shall, in collaboration with the Secretary, encourage the gift of funds to the Institute.

Section 11. The Finance Committee shall have charge and supervision of all securities and general funds of the Institute including any funds derived from bequests and endowments. It shall invest all general funds available for investment. It shall pay the income from all investments to the Treasurer of the Institute. It shall approve the annual budget as to form and expected income from invested funds before it is presented to the Board for final approval, and shall thereafter make such examinations of financial results of operations as will insure compliance with the annual budget. It may, with the approval of the Board of Managers, appoint a Trust Company of the City of Philadelphia to act as Fiscal Agent under the direction of the Committee.

Section 12. The Library Committee shall have charge of the library and, in collaboration with the Secretary, purchase books and publications suitable to and consonant with the purposes of the library of the Institute.

Section 13. The Meetings Committee shall, in collaboration with the Secretary, secure for presentation before the Institute papers dealing authoritatively with subjects of import in the fields of science, engineering and industry.

Section 14. The Membership Committee shall, in collaboration with the Secretary, promote the several memberships defined in ARTICLE II of these By-Laws.

Section 15. The Memorial and Museum Committee shall, in collaboration with the Secretary, be of counsel and advice to the Director of the Benjamin Franklin Memorial and The Franklin Institute Museum, and with the scientific staff of the Museum concerning the activities and the exhibits of both the Memorial and the Museum.

Section 16. The Publications Committee, in collaboration with the Secretary, shall have charge of all publications of the Institute

other than publications of the Bartol Research Foundation.

Section 17. Each committee shall organize and adopt rules as it sees fit, subject to the provisions of these By-Laws and the approval of the Board of Managers.

ARTICLE IX.

MEETINGS.

Section 1. The Institute shall hold stated meetings on the third Wednesday of each month except in June, July, August and September, at 8:30 P.M.

Section 2. Special meetings shall be called by the President upon the order of the Board of Managers or within ten days upon the written application of twenty-four voting members of the Institute.

Section 3. Twenty-four members shall constitute a quorum at any stated or special meeting.

Section 4. The Annual Meeting of the Institute shall be held on the third Wednesday of January of each year at 8:30 P.M. Elections at Annual Meetings shall not result from the poll of less than forty-eight ballots cast in accordance with ARTICLE IV, Section 5, of these By-Laws.

ARTICLE X.

AMENDMENTS.

These By-Laws may be altered or amended at any stated meeting of the members of the Institute, provided notice in writing, signed by two members, of the proposed alteration or amendment, shall be given to the Board of Managers two months prior to the said meeting, except that amendments to ARTICLE I, relating to capital stock, must be ratified subsequently by a majority of the stock represented at a meeting specially called for this purpose.

The BRF Blood Plasma Substitute and Its Restorative Effect After Acute Hemorrhage.—J. O. ELY. The BRF Blood Plasma Substitute has been studied from various aspects since it was first reported (Ely, J. O., and Angulo, A. W., *Journal of the Franklin Institute*, **235**: 197, February, 1943).

The constitution of the BRF Blood Plasma Substitute is as follows:

	Constituents	Grams
Solution 1.	Gelatin, Baker's U.S.P.	5.400
	Cysteine.HCl	0.018
	Phenol Red	0.010
	Sodium Chloride	1.440
	Potassium Chloride	0.036
	Calcium Chloride (anhydrous)	0.036
	Magnesium Chloride.$6H_2O$	0.018
	Sodium Di-hydrogen Phosphate	0.009
	Distilled Water	100 cc.
Solution 2.	Glucose	6.000
	Distilled Water	100 cc.

V.23
1945

Solution 1 was sterilized by placing it in an autoclave for 30 minutes at 20 lbs. steam pressure. Solution 2 was sterilized by passing it through a Seitz sterilization filter pad. The two solutions were then mixed and designated BRF Blood Plasma Substitute.

The original idea of the composition of the substitute came from media found adequate for the life of cells in tissue culture.

Its first application was in the treatment of burns to counteract the concentration of red blood cells (hemoconcentration) in the vessels and the loss of fluid coincident therewith. The plasma substitute was studied for toxicity, antigenicity, etc. It was studied for its effect upon growth of animals. It was also studied electrophoretically by means of the Tiselius apparatus to determine any changes in the blood proteins and the fate of the gelatin which disappears from the blood in 24 hours. No unfavorable results were found and it was non-hemolytic. The BRF Blood Plasma Substitute and blood plasma itself were found to be equally effective in combating the hemoconcentration of burns while 0.85 per cent. sodium chloride had no apparent effect.

Here will be reported the restorative effects of the plasma substitute in acute hemorrhage simulating severe bleeding after wounds.

Three methods of bleeding, (1) from the ear, (2) from the femoral vein, (3) from a jugular vein, proved unsatisfactory. Since these methods failed, the seemingly more objectionable method of bleeding by heart puncture was adopted. This method proved more satisfactory

than was anticipated, after experience with the first few animals. For example, the last eight animals were bled without loss or apparent injury, except for the one heart puncture in each.

Unfasted rabbits were given Evipal intravenously until they were sufficiently anesthetized to obviate struggling during the removal of blood from the heart. A needle was then inserted and the blood withdrawn. The time necessary for bleeding was approximately five minutes. The BRF Blood Plasma Substitute was injected into an ear vein. In order to avoid death injections were begun immediately after removal of the blood. The results are tabulated in Table I.

TABLE I.

Effect of BRF Blood Plasma Substitute in Acute Hemorrhage in Rabbits.

Rabbit Number	Weight grams	Blood Removed cc.	Blood Removed %	Effects of Blood Removal	BRF Soln. Injected cc.	Effects of BRF Soln.
2	2330	77	60	Respiration faint, heart action very weak.	none	Died in 15 min.
3	2838	102	65	"	none	Died in 15 min.
4	2690	86	58	"	none	Died in 20 min.
5	2859	95	60	"	none	Died in 15 min.
6	2874	95	60	"	60	Lived
7	—	—	—	Injured in taking blood, bled into thoracic cavity.	—	—
8	—	—	—	"	—	—
9	2540	72	49	Couldn't obtain more blood, respiration ceased.	60	Lived
10	—	—	—	Insufficient anesthetic, struggling, heart injury.	—	—
11	2239	74	60	Respiration ceased, heart action very weak.	60	Lived
12	2268	75	60	"	50	Lived
13	2948	92	56.3	Couldn't obtain more blood, respiration ceased.	60	Lived
14	2139	71	60	Respiration ceased, heart action very weak.	30	Lived
15	1531	51	60	"	25	Lived
16	1984	66	60	"	30	Lived
17	2041	68	60	"	35	Lived
18	1673	50	54.6	"	30	Lived

The removal of 60 per cent. of the blood volume resulted in death in four rabbits which were not treated after bleeding. It seems certain that without treatment all of the rabbits would have died because respiration stopped and the heart action was very weak as determined by the stethoscope. Immediately after beginning the injection of BRF Blood Plasma Substitute into such rabbits there was a prompt improvement in the heart action. Artificial respiration, in some cases forced exhalation into the rabbits' lungs by a worker, was necessary to restore the breathing. From this point on recovery appeared to be uneventful.

In all rabbits the strengthening of the heart action and the improvement of respiration, once it was restored, testify to the efficacy of the BRF

Blood Plasma Substitute under the conditions of these experiments. No objectionable features of the treatment were observed.

In this work the average value of 5.8 per cent. of the body weight was assumed to be the amount of blood in the rabbit. This is the average figure given by Scarborough (*Yale Journal of Biology and Medicine*, **3**: 63, 1930). The average specific gravity of the blood was assumed to be 1.05.

The average to-death-bleeding of 17 dogs was found by Lawson (*American Journal of Physiology*, **140**: 420, 1943) to be 5.32 per cent. of the total body weight. Scarborough gives the average blood volume of the dog as 9.2 per cent. of the body weight. If we accept these figures as averages, Lawson removed 57.1 per cent. of the dog blood. Thus the 60 per cent. removed in our rabbit experiments is of the same magnitude. In addition, the rabbit blood was removed much more rapidly than the dog blood. This rapid removal must have been an added strain on the rabbits. The results justify the conclusion that in addition to its usefulness in combating hemoconcentration in burns, BRF Blood Plasma Substitute may serve as an effective replacement agent in acute hemorrhage.

BOOK REVIEWS.

THE AMERICAN ANNUAL OF PHOTOGRAPHY, Volume 59, 1945. 200 pages, illustrations, 18 × 25 cms. Boston, American Photographic Publishing Co., 1944. Price $.50 (paper).

Lovers of the camera—and their name is Legion—will accord its usual welcome to the American Annual of Photography, and this 1945 edition should in no way disappoint them. Even those who are content to admire the work of others may rejoice in the illustrations, and there is an article on "Photographing Dogs and Cats in the Home" with entrancing puppies and kittens to delight them. This is balanced by a discussion of present practice in medical photography with instructions in technique, and also by the opening article on "Aspects of Color" by Lloyd E. Varden. For human interest, there is an account of the life of Edwin Hale Lincoln, who won his national reputation with his marines, turning later to botany and the detailed pictures of wild flowers, while the paper on "Photography in the Study of Design" should satisfy the most convinced modernist. The Annual is now in its fifty-ninth year and its continuing popularity seems richly deserved.

E. EWING.

THE THEORY OF RESONANCE AND ITS APPLICATION TO ORGANIC CHEMISTRY, by George Willard Wheland. 316 pages, tables and illustrations, 14 × 22 cms. New York, John Wiley and Sons, Inc.; London, Chapman and Hall, Ltd., 1944. Price $4.50.

The theory of resonance as applied to chemical structural theory is a man-made concept in a more fundamental sense than most other physical theories. It does not correspond to any intrinsic property of the molecule itself, but instead it is only a mathematical device, deliberately invented by the physicist or chemist for his own convenience. The theory is perhaps the most important addition to chemical structural theory since the concept of the shared electron bond was introduced by G. N. Lewis. The purpose of this book as stated by the author is to provide a comprehensive survey of the subject to satisfy a need due to the scarcity of such in the literature.

The procedure followed in this presentation begins with a treatment on the theory of resonance and the nature of valence. Here it is shown how the principle of resonance energy accounts in a qualitative way for the existence of covalent bonds and so, in a certain sense, for the existence of chemistry itself. Later its application to the less fundamental but more familiar problem of resonance among ordinary valence bond structures is taken up. Subsequently the steric effects of resonance are discussed and dipole moments, molecular spectra, chemical equilibrium, and chemical reaction. There are a number of useful appendixes and a subject and author index.

The work is presented from the chemical viewpoint, detailed and rigorous. It should go far toward accomplishing its purpose.

R. H. OPPERMANN.

ELECTRIC CIRCUITS AND FIELDS, by Harold Pender and S. Reid Warren, Jr. 534 pages, illustrations, 14 × 22 cms. New York and London, McGraw-Hill Book Co., Inc., 1943.

This is a textbook on basic topics in electrical engineering for students who have had college courses in differential and integral calculus and in general physics. It is arranged in two parts, the first being devoted to electric circuit problems, which involve the investigation of the measurable effects of electric currents, either constant or varying with time. Beginning with fundamental concepts, the work proceeds through direct current calculations, sources of electromotive force, introduction to transient phenomena, sinusoidal alternating currents, the

use of complex numbers in solving alternating current networks, polyphase circuits and symmetrical components, filters and transmission lines, and non-linear circuits. The approach to the various topics is usually made in line with the practical aspects. As an illustration of this, the part of the book devoted to transient phenomena contains derivations of differential equations and their solutions on the basis of electric circuit theory. Emphasis is placed on the presentation of the solutions and a discussion of their meaning from the physical point of view and not upon their derivation.

Part two is devoted to electrostatic and electromagnetic fields. Continuity of progression between the two parts is seen in the derivation of formulas from an elementary point of view as special cases of more general relations derived in the latter part. As an example, the equations of circuit theory are derivable from the theories of electric and magnetic fields. In this second part of the book the elementary theory of electrostatics is the first subject of discussion. This leads to further development of the theory and its applications to a number of important engineering problems. The phenomena and theories associated with charges that are accelerating relative to the observer are subsequent topics, and the applications of the theories to several engineering problems are discussed.

There are several appendixes including notes on vector analysis, electrostatic potential in the neighborhood of the very long electrically-charged cylinders, and the vector potential as the basic quantity for the correlation of magnetic phenomena. A subject and author index completes the work. There are many pertinent problems for exercise at the ends of chapters.

This is a text which has a special feature of flexibility of application. It should interest teachers of electrical engineering.

R. H. OPPERMANN.

V.23
1945

THE MODERN GAS TURBINE, by R. Tom Sawyer. 216 pages, diagrams and illustrations, 16 × 24 cms. New York, Prentice-Hall, Inc., 1945. Price $3.00.

Engineers for a long time have contemplated the possibilities of the gas turbine. Like many other ideas, it started with observation of the forces of nature and little by little this has been developed and added to until there is quite an array of data at hand. A preview of the early history of the gas turbine reveals the interesting fact that practically all basic patents have been granted. But there is yet to be done the work of finding and developing satisfactory materials for its construction.

The stated purpose of this book is to inform executives and engineers as to the latest applications of the gas turbine as a supercharger and prime mover. The treatment is descriptive in nature, using many drawings and photographs, and only a minimum of the more simple mathematics. Fundamentals are first explained, followed by a coverage of early inventions and history of the gas turbine. The various systems of its use employing diesel engine exhaust gases, as a supercharger or as a prime mover, are gone into, indicating that the exhaust from practically any type engine can be used to drive a gas turbine, provided that each is properly coordinated in design. There is an interesting chapter on calculations and efficiencies of combustion gas turbines showing definite possibilities worthy of development. The book then leads into discussions on the gas turbine in industry, in marine service, in locomotive application, the exhaust turbosupercharger on aircraft engines, and as an aircraft prime mover including jet propulsion. Of particular interest with regard to the future of the gas turbine in aviation is the summary that from a long range viewpoint the gas turbine with a propeller fits aircraft requirements probably better than it does any other kind of service, and owing to the trend in aircraft operation toward flying at higher speeds and higher altitudes, the gas turbine propeller unit promises to offer better performance than can be obtained with the conventional aircraft engine.

The book provides an interesting way of becoming acquainted with this promising development.

R. H. OPPERMANN.

FORMALDEHYDE, by Frederic J. Walker. 397 pages, illustrations, 15 × 23 cms. New York, Reinhold Publishing Corporation, 1944. Price $5.50.

Formaldehyde is a material of many uses and of increasing industrial importance. The fact that formaldehyde production has grown almost continuously since the first decade of the twentieth century, reaching a figure of approximately 180 million pounds in 1940, is ample evidence of the magnitude of its use. The growth and the possibilities of the future have created a need for a book encompassing the field, its development, technique, and present state, and this American Chemical Society Monograph has been compiled in response.

The opening is a brief chapter on formaldehyde production dealing with methods of manufacture from methanol, and from methane and other hydrocarbon gases. Then, in discussing formaldehyde chemistry, attention is focused on the physical and thermodynamic properties of the various formaldehyde substances; the simple monomer, formaldehyde solutions, and polymers. The chemical properties of formaldehyde are next taken up including reactions with inorganic agents, aliphatic hydroxy compounds and mercaptans, aldehydes and ketones, phenols, carboxylic acids, acid anhydrides, acyl chlorides, esters, amino and amido compounds, and with hydrocarbons and hydrocarbon derivatives. A review is made in detail of methods generally applicable for detecting formaldehyde alone or in the presence of other compounds with which it is commonly associated, and special emphasis is placed on methods which make it possible to obtain some estimate of the quantity of formaldehyde involved. Procedures for quantitative analysis are discussed. Hexamethylenetetramine is given special consideration, for it plays an important industrial role as a special form of formaldehyde. The industrial applications of commercial formaldehyde substances, viz., formaldehyde solution, paraformaldehyde, and hexamethylenetetramine, are discussed in the latter part of the book. In this connection it is stated that this monograph makes no attempt to replace the many excellent works of reference which deal with formaldehyde resins. The emphasis is to the many other miscellaneous applications which have received less attention in previous publications.

The work contains lists of many references to all the topics covered and there is a comprehensive subject index in the back. It takes its place alongside other American Chemical Society Monographs as a valuable volume marking progress and pointing to the future.

R. H. OPPERMANN.

COLLEGE PHYSICS, by C. E. Mendenhall, A. S. Eve, D. A. Keys and R. M. Sutton. 693 pages, illustrations, 16 × 24 cms. Boston, D. C. Heath and Company, 1944. Price $4.00.

Physics as a basic study for engineering cannot be emphasized too much. Not only is preparation made in physics for engineering but a like or dislike is developed, which may be of even as great importance. The method of approach, clarity and continuity therefore stand alongside content and scope in a good physics text. And another point that should not be passed over lightly is the fitting of the text to the particular situation of the student. If the exact prerequisites are not had, discouragement may result.

The book at hand is an introductory course in physics for university or college students. The mathematical requirements have been kept to a minimum, nothing beyond algebra and trigonometry, and the coverage is not too technical for the student of average ability. The subdivisions of physics are taken up in the usual order. Mechanics is first taken up dealing with motion, energy and power, mechanics of gases, and properties of fluids, which leads into wave motion and sound. Heat is next, followed by magnetism, electricity, then radio, from which connection is made with light. The topics of photoelectricity and radio activity are preparatory to an up-to-date presentation of atomic physics and the newer aspects of radiation phenomena. There are nearly 600 illustrations and diagrams, besides many tables of data in the 660 pages of text.

The authors are firm believers in the use of exercises to make lasting impressions, and aside from the practical nature of the exercises, the good feature of answers is given in the back of the book. Closely allied with this are the shorter divisions or chapters in the book.

This makes for simpler orientation and classification of the parts of the study, often quite valuable.

The book is a clear presentation, a logical and smooth progression, of adequate coverage of the subject. It is a useful text for the classroom and for home study. The subject index makes it useful as a reference.

R. H. OPPERMANN.

PUBLICATIONS RECEIVED.

The Modern Gas Turbine, by R. Tom Sawyer. 216 pages, diagrams and illustrations, 16 × 24 cms. New York, Prentice-Hall, Inc., 1945. Price $3.00.

Formaldehyde, by J. Frederic Walker. 397 pages, illustrations, 15 × 23 cms. New York, Reinhold Publishing Corporation, 1944. Price $5.50.

CURRENT TOPICS.

ARMY AND NAVY NOTES.

Giant West Coast Wind Tunnel for Testing Full-Size Planes.—Preparations for investigations of full-size airplanes under simulated flight conditions are complete at the National Advisory Committee for Aeronautics in Ames Aeronautical Laboratory. Engineers are at the end of a war-vital job that has taken more than three years: building a full-scale aeronautical wind tunnel larger than any other in the world. The Moffett Field wind tunnel dwarfs even the N.A.C.A. full-scale wind tunnel at Langley Field, Va., which previously was the largest in the world.

The huge new tunnel now is ready to play its important war role of helping to keep the United Nations ahead of the Axis powers in the air, then to be of continuing importance to both military and commercial aircraft of the future.

Assisting the Ames engineers and also working on night-and-day schedules are engineers for the Westinghouse Electric and Manufacturing Company, who helped install and test the six giant 6,000-horsepower Westinghouse electric motors and other allied apparatus which powers and controls the "hurricane." Each of the 57-ton motors drives a six-bladed spruce fan 40 feet in diameter; about the height of an average four-story building.

Basically, the task at Ames Laboratory and at other aeronautical research centers is simply to improve aircraft; to enable the designing and building of faster, safer, more efficient airplanes. Majoramong the problems is the reduction of "drag," or cutting down the effect of various forces which impede forward motion of an airplane. Another is termed "lift," the force which keeps the plane afloat, as distinguished from gravity, which tends to pull it back to earth.

The test section in the full-size tunnel is 80 feet wide and 40 feet high. This will enable the testing not only of full size planes including some of the two-engine types, but also of extraordinarily large models of the largest planes. Air speeds to be attained in the tunnel were not revealed.

Everything about the new tunnel is big. The 6,000-horsepower motors, for example, weigh approximately 114,000 pounds apiece, about 40 times the weight of a medium-priced sedan, and measure 21 feet long by 10½ feet in diameter. They are mounted in two horizontal rows of three, one row above the other in a 90- by 128-foot portion of the wind tunnel opposite the test section. Center line of the top row of motors is nearly 90 feet above ground level.

Each motor will drive a six-bladed spruce propeller, 40 feet in diameter, at any desired speed from 50 to 288 revolutions a minute. At top speed, tips of the fans will travel more than 6.85 miles a minute; about 411 miles an hour.

The six motors will consume a total of about 30 million watts of electrical energy; power enough to meet the average current requirements of approximately 30,000 homes, Westinghouse engineers estimate. Current from a 110,000-volt power line will be stepped down to 6,600 volts, by transformers, for delivery to the motors.

Operating at maximum speed, each of the motors will require 25,000 cubic feet of air per minute, simply to keep it cool. Total volume of cooling air delivered to all six motors, 150,000 cubic feet per minute, would supply the normal breathing requirements of more than 450,000 people, or all residents of a city approximately the size of Cincinnati, Ohio, it is estimated.

Despite size and bulk of the installation, starting or stopping the battery of six motors can be accomplished merely by pressing a button. Control of the huge motors presented Westinghouse and Ames engineers with problems seldom met on as large a scale. Solution was found in an application of what is known as the modified Kraemer control system. This system, an arrangement of electric motors and generators, will serve to start the fan motors and get them up to the desired speed with minimum disturbance to the power line; will enable smooth, synchronized operation of the six motors over a wide range of speeds, and will convert a large percentage of potential power losses back into usable energy.

Motor-generator sets comprising the control system are even larger and heavier than the motors. One set is 39 feet long, 11 feet high and weighs 405,000 pounds. Smaller similar unit measures 26 feet long, 9 feet high, and weighs 135,000 pounds.

R. H. O.

The Thermistor.—The Western Electric Company has added the thermistor to its long list of electronic and communications equipment now being manufactured for the Armed Forces. Like many other products that have come of age during this war, thermistors will have a vast number of peacetime applications in the electronic world of tomorrow.

The thermistor was designed by Bell Telephone Laboratories and is a small circuit element made of a mixture of metallic oxides which are pressed into discs, extruded into rods, or formed into tiny beads. These metallic oxides are members of a class of materials known as semi-conductors, which are characterized by high negative temperature coefficients of resistance. In other words the electrical resistance of the semi-conductor decreases rapidly as its temperature rises and conversely the resistance increases as its temperature falls. Temperature coefficients of resistance as great as 5 per cent. per degree Centigrade are available. Although some knowledge of the behavior of semi-conductors dates back to the time of Faraday, they were long neglected, and only in recent years have the Laboratories, after intensive study, succeeded in stabilizing their characteristics and assuring indefinitely long life.

Thermistors and their special characteristics may be used in electrical circuits wherever temperature changes can be produced. There are three basic ways of varying the temperature; externally, directly, and indirectly. If the ambient temperature rises, the resistance falls accordingly. If a current is passed through a thermistor, heat is produced internally, the temperature rises and the resistance lowers. If a small coil of wire is placed very close around the thermistor and a current is passed through it, heat is produced by the coil which in turn warms the thermistor and lowers its resistance. The unit is then said to be indirectly heated. Thus by suitable electrical connections, changes in the thermistor resistance may be used for measurement or for control of ambient or circuit conditions as desired.

V.2
194

One of the older types of thermistors, the 1C, which may be known to some electronic engineers, will typify the operation of the 30 to 40 types now in manufacture. This is a directly-heated type of thermistor and consists of a minute bead of oxides suspended on fine wires and enclosed in a nitrogen-filled glass bulb with two wire terminals. This assembly is further encased in an insulating tube with metal contacts on the ends, much like a fuse housing. The overall length of the completed unit is approximately $1\frac{5}{16}$ inches, and the outside diameter is about $\frac{1}{4}$ inch.

A 1C thermistor, at room temperature, has a resistance of approximately 50,000 ohms. As current flows through the oxide bead, the unit is heated and its resistance decreases. To demonstrate the extent of the decrease brought about by the resistance versus power characteristics of the unit, let us raise the power input to 18 milliwatts. At this point the resistance of the unit will be approximately 18,000 ohms, showing a decrease of approximately 32,000 ohms. When 100 milliwatts is applied, the resistance will be approximately 500 ohms.

The thermistor will trace and retrace the characteristics here indicated without appreciable deviation over an indefinitely long life. Laboratory tests have indicated that the thermistor's characteristics are stable and substantially unchanged after more than a half-million heating cycles. Other thermistors have been studied and found to yield equally good life performance.

The thermal and electrical characteristics of externally, directly, and indirectly-heated thermistors suggest a vast number of possible circuit applications. New thermistors are continually being developed for use in amplifiers, oscillators, voltage regulators and volume limiters. In these devices they serve a variety of functions such as stabilization, temperature compensation or time delay.

When placed in the proper bridge circuits, thermistors may be used as flow meters, as vacuum gauges, or, in general, to measure physical quantities dependent upon the flow of thermal energy from a hot body. When used as resistance thermometers, precision greater than that obtainable with thermocouples is possible, or the same precision can be obtained with similar equipment. Temperature regulation can be accomplished with thermistors and relatively simple associated equipment. Frequently this results in lower production costs.

As a temperature compensator, the thermistor may be used to compensate for changes in resistance due to ambient temperature variations in circuits having a positive coefficient of resistance.

As variable resistance devices, thermistors have important use in automatic transmission-regulating networks.

Standard relays, subject to false operation caused by high voltage surges, have been converted into slow-acting devices by putting directly heated thermistors in series with their windings.

R. H. O.

Ship to Shore by Water. (*Compressed Air Magazine*, Volume 49, No. 9.)—Waterproof bags are a vital factor in our Italian and southern Pacific campaigns because they make it possible to transfer delicate equipment and perishable supplies from ship to shore as soon as a vessel reaches port. The containers

were developed for the U. S. Signal Corps by the United States Rubber Company and use natural air to give them the buoyancy needed to keep them afloat. The air is trapped in the top of the bags which, with their load, are guided through the water either by swimmers or by guy lines.

The bags are made of heavy duck coated both inside and outside with natural and reclaimed-rubber compounds. They are not more than $\frac{3}{16}$ inch thick and vary in weight from 3 to 8 pounds, depending upon size and carrying capacity. They serve primarily to get medical supplies, instruments, and food ashore, as well as Signal Corps equipment, so that field hospitals can be set up and telephonic and radio communication established without delay. With that work done, they are used to protect materials in outdoor storage. These bags will withstand complete submergence in water for more than six days without letting in a drop of water or permitting dampness to penetrate.

R. H. O.

Curare—Poison and Medicine.—A recent issue of *Agriculture in the Americas*, a monthly publication of the Office of Foreign Agricultural Relations, U. S. Department of Agriculture, contains an article by J. Gordon Leahy of which the following are excerpts.

"The South American arrow poison which was first mentioned in the English language in 1596 in Richard Hakluyt's description of Sir Walter Raleigh's expedition to British Guiana is curare, a poison that is still being used on blowgun darts in sections where ammunition and guns are difficult to obtain.

"'The making of curare generally consists of boiling down a concoction of selected ingredients from bark, roots, stems, and tendrils of the different species of plants, skimming off impurities, filtering the residue, adding the chosen catalytic agents (such as Annona ambotay, Capparis sola, or others), and boiling to a syrup. The syrup is exposed to the sun in flat earthen vessels so that the curare will thicken into a paste. When ready it is placed in clay gourds, or calabashes, that are tightly covered. It is often put into bamboo tubes to be exchanged for the goods of other tribes and hunters unable to make curare. If the curare loses strength, this can be restored by adding the juice of Manihot utilissima or Annona ambotay and burying it in a well-covered calabash set in warm earth for a day or two.'

"Today curarine, the alkaloid extracted from curare, is used in medicine to protect patients against injuries likely to occur in shock therapy for mental diseases, and in many cases it has made this shock treatment possible for persons who otherwise would have been unable to stand it. The drug is valuable, too, in eye, ear, nose, and throat work and for certain diagnosis and surgical operations, but it is not an anaesthetic.

"From the crude use of curare on the darts of savages to its highly specialized and carefully controlled use in modern medicine is a long jump."

R. H. O.

Research Develops New Coating Material.—A new type resinous coating material that looks like varnish, withstands high temperatures and the action of most chemicals and solvents, and can be made from sugars and starches of farm crops, has been developed by the Research Administration of the Department of Agriculture.

The product, known as "allyl starch," is prepared by treating starch with either allyl chloride or allyl bromide and is quite different from the carbohydrate compounds previously made by this method. When freshly prepared, allyl starch and other allyl carbohydrates are soluble in most paint and varnish solvents, which makes possible their ready application to wood, metal, paper, glass, textile and other surfaces. Upon "curing," in contact with air or by application of heat, they undergo complex chemical changes that produce a hard, smooth surface which is extremely resistant to organic solvents, acids, alkalies, and other corrosive agents. Properly cured coatings have withstood temperatures of 400° Fahrenheit. Alcohol, gasoline, acetone and other liquids spilled on the surface coated with allyl starch left no mark. Boat flag poles coated with this material and subjected to continuous day and night service and the abnormal climatic changes from hot to cold and wet to dry, are standing up surprisingly well in experimental tests.

Allyl starch and other allyl carbohydrates, which were developed by Dr. Peter L. Nichols, Jr. and Robert M. Hamilton in the Bureau of Agricultural and Industrial Chemistry's Eastern Regional Laboratory at Philadelphia, should be especially valuable in the preparation of lacquers, varnishes, cements, and impregnating compounds. The coating is easily applied, and possesses such desirable characteristics as transparency, high gloss, hardness, and adequate flexibility. The materials used in making this product are thermosetting, which means they will harden under heat or pressure as well as under ordinary atmospheric conditions. The new coating can be produced easily and all indications are that it will find wide application as a protective coating —particularly for interior use and in the plastic field.

"This new discovery," says Dr. O. E. May, chief of the Bureau of Agricultural and Industrial Chemistry, "promises to open a whole new field for the industrial utilization of surplus starches and sugars." The development is now in the pilot plant or semi-commercial stage.

R. H. O.

Scientific Fungus Farm.—A scientific fungus farm—one of the first of its kind—has been established at General Electric's Schenectady Works Laboratory so that engineers, by studying the characteristics of the mysterious growth, may prevent its interfering with the best performance of war equipment.

Fungus growth collects from spores which crowd the air. After settling on a surface, they collect in soggy colonies. These are what menace delicate equipment. They feed on the insulation wrapping of wires, often short-circuiting important connections. They clog machinery. And they give off a by-product which forms an acid strong enough to corrode metallic and electrical parts.

According to the findings of G-E researchers, there are 200 varieties of the spongy-fungus mold. One of these gave science the magical new drug, penicillin. Like mushrooms, fungi thrive in warm, moist places, do not need light. Their distribution is apparently not limited to definite areas, for wind carries them so easily that under the right conditions any type might appear at any place.

In the tropics, where the atmosphere conditions are especially to their

liking, the fungi flourish and often disrupt essential equipment. To protect it, the Army Signal Corps has set up specifications for materials to be used and has encouraged research on ways to prevent the colonies from thriving.

At General Electric, scientists are experimenting with new-type waxes, lacquers and varnishes to develop one that will have a toxic effect on the growth. Their purpose is not to kill off the fungi, which now seems highly improbable, but to arrest their development in the early stages and prevent their clustering into colonies.

Research has shown that the colonies can be arrested naturally under certain conditions. Thus they can be prevented from forming if the humidity is held below 75 per cent. of the atmosphere, if the equipment is enclosed in water-tight cases or if the surface is kept spotlessly free of dust.

Since these natural conditions are almost impossible to regulate in theaters of war, however, most research is trying to develop a powerful fungicide that will penetrate the walls of the spores, stop their growth and prevent the mold from beginning.

Several fungicidal varnishes and lacquers have already been developed for general use, but none has yet been found to meet all the desired requirements, G-E scientists declared. To be completely effective, a fungicide would have to arrest the parasitic growth, be nonpoisonous to humans, noncorrosive, permanent and colorless. Of those now in use, the phenyl mercuric type appears to conform most closely to requirements.

The goal of the General Electric staff, one of several working on the project, is to improve on various fungicides now in use and to develop new ones. They have found that whereas fungicides will continue to be effective several months at room temperature, they lose their power in a day or two when the temperature is from 120 to 140 degrees. In line with army requirements, their ultimate aim is to produce a fungicide that is more permanent as well as more effective.

R. H. O.